INSTRUCTION MANUAL

BK PRECISION®

MODEL 1823

175 MHz UNIVERSAL COUNTER

BK PRECISION®

TEST INSTRUMENT SAFETY

WARNING

Normal use of test equipment exposes you to a certain amount of danger from electrical shock because testing must sometimes be performed where exposed high voltage is present. An electrical shock causing 10 milliamps of current to pass through the heart will stop most human heartbeats. Voltage as low as 35 volts dc or ac rms should be considered dangerous and hazardous since it can produce a lethal current under certain conditions. Higher voltage poses an even greater threat because such voltage can more easily produce a lethal current. Your normal work habits should include all accepted practices that will prevent contact with exposed high voltage, and that will steer current away from your heart in case of accidental contact with a high voltage. You will significantly reduce the risk factor if you know and observe the following safety precautions:

1. Measurements should never be made at circuit points that exceed 200 V peak or damage to the instrument may occur. Even when measurements are made at low voltage points, be careful to avoid touching any high voltage point.
2. When testing ac powered equipment, remember that ac line voltage is usually present on some power input circuits such as the on-off switch, fuses, power transformer, etc. any time the equipment is connected to an ac outlet, even if the equipment is turned off.
3. If possible, familiarize yourself with the equipment being tested and the location of its high voltage points. However, remember that high voltage may appear at unexpected points in defective equipment.
4. Use the time-proven "one hand in the pocket" technique while handling an instrument probe. Be particularly careful to avoid contacting a nearby metal object that could provide a good ground return path.
5. Don't expose yourself high voltage needlessly. Remove housings and covers only when necessary. Turn off equipment while making test connections in high-voltage circuits. Discharge high-voltage capacitors after removing power.

(Continued on inside rear cover)

Instruction Manual
for
Model 1823

175 MHz
Universal Counter

B+K PRECISION®
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INTRODUCTION

The **B&K-Precision** Model 1823 Universal Counter is a high-quality, lightweight counter capable of frequency measurements from 5 Hz to 175 MHz. It features an eight-digit display which provides up to 0.1 Hz resolution at all frequencies below 10 MHz, and 1 Hz resolution at all frequencies to 175 MHz.

In addition to frequency measurements, the versatile Model 1823 also provides a number of other very useful operating modes.

In period mode, the unit measures the period (in microseconds or milliseconds) of one cycle, over the range of 5 Hz to 2 MHz. At low frequencies, much greater accuracy can be achieved by period measurement than by frequency measurement.

In frequency ratio mode, frequencies of two input signals are compared and their ratio displayed. This is useful in cases where a number of different signals are related to some reference, such as a clock signal in digital circuits.

In time interval mode, the counter measures the elapsed interval (in microseconds or milliseconds) from a selected edge of one input signal to a selected edge of another. Time interval mode is especially useful in duty cycle measurements, where both inputs are connected to the same signal and different edges are selected to display "on" or "off" time. Measurement of time interval between two "once-only" events is also possible.

Totalize mode permits counting of individual events. The counting process can be gated, either manually by a front panel switch, or by a gating signal applied to a rear panel jack, for more exact electronic control.

A self test mode is also provided which enables a quick check of several facets of instrument operation.

Each operating mode, and one of four decades of resolution are selected by a front panel pushbutton switch. Easy to interpret readouts are provided by large bright digits, automatic decimal point placement, leading zero blanking, and LED display of proper measurement units. Overrange and GATE function (indication of a measurement in progress) are also shown on front panel indicators.

A number of signal conditioning controls are provided to prevent mis-counting due to input noise, etc. These include edge selectors and selectable X10 attenuators for both channels, and a 10 kHz low-pass filter and variable trigger threshold control for Channel A.

A front panel HOLD switch is provided which "freezes" the display at the present reading, as well as a RESET button which clears the counter display and initiates a new measurement when released.

The standard input impedance of one megohm in conjunction with a 10:1 oscilloscope probe makes this instrument ideal for use in applications where source loading must be kept to a minimum.

The internal 10 MHz time base is generated by a crystal controlled oscillator for good stability with regard to temperature (±10 ppm, 0°C to 50°C) and line voltage variation (±1 ppm for 10% variation). An external 10 MHz reference oscillator with a better temperature stability may be applied externally thru a rear panel jack.

The exceptional accuracy, sensitivity, and versatility of this counter makes it an extremely valuable instrument to the scientist, engineer, experimenter, and communications technician. Its ruggedness and compactness make it practical for use by the hobbyist or field technician.

SPECIFICATIONS

FUNCTIONS

Frequency.
Period.
Period Average.
Ratio.
Time Interval.
Totalize.
Check (Self Test).

FEATURES

8 Digits, 0.56″ High.
Dual Input.
2-Position Attenuator (Ch. A & Ch. B).
Selectable Trigger Slope (Ch. A & Ch. B).
Adjustable Trigger Level (Ch. A)
Low Pass Filter (Ch. A)
External Time Base Input

FREQUENCY A

Range: 5 Hz to 175 MHz sine wave:
5 Hz to 10 MHz in kHz mode,
50 kHz to 175 MHz in MHz mode.

Resolution: 0.1 Hz to 1 kHz, in decade steps.

Accuracy: ±1 count ± time base error.

Display: kHz or MHz with decimal point.

PERIOD A

Range: 0.5 µs to 200,000 µs.

Freq. Range: 5 Hz to 2 MHz sine wave.

Resolution: 100 ps to 100 ns in decade steps.

Accuracy: ±1 count ± time base error ±trigger error[1].

Display: ms or µs with decimal point.

Minimum Pulse Width: 250 ns.

Average: 1, 10, 100, or 1000 cycles averaged.

RATIO A/B

Range A: 5 Hz to 10 MHz sine wave.

Range B: 5 Hz to 2 MHz sine wave.

[1]**NOTE:** Trigger error is typically ±0.3% of reading divided by the number of cycles averaged, for input signals having better than 40 dB S/N ratio and greater than 100 mV amplitude.

RATIO A/B (cont.)

Resolution: $\frac{\text{Freq B}}{\text{Freq A x N}}$ where N = 1, 10, 100, or 1000

Accuracy: $\pm\frac{\text{Freq B}}{\text{Freq A x N}}$ ± trigger error[1].

Display: Numerical ratio with decimal point.

TIME INTERVAL A TO B

Range: 0.5 µs to 200,000 µs.

Freq. Range: 5 Hz to 2 MHz, sine wave.

Resolution: 100 ps to 100 ns in decade steps.

Accuracy: ±1 count ± time base error ± trigger error[1] ±N, where N = intervals averaged.

Minimum Pulse Interval (A to B): 250 ns.

Display: msec or µsec with decimal point.

Average: 1, 10, 100, or 1000 intervals averaged.

Single Event Capability: Pressing RESET primes unit for measurement of "once-only" event.

TOTALIZE A

Range: 5 Hz to 10 MHz sine wave.

Count Capability: 0 to 99,999,999 before OVERFLOW.

Control: Manual reset and hold from the front panel. Normally enabled, except when signal at back panel START/STOP jack is low.

CHECK (SELF TEST)

Display: 10 MHz with user-selectable MHz, kHz.

Gate Times: 10 ms, 100 ms, 1 s, or 10 s accumulation times.

Resolution: 0.1 Hz to 100 Hz.

CHANNEL A INPUT CHARACTERISTICS

Bandwidth: 5 Hz to 175 MHz, ac coupled.

Sensitivity: 5 Hz to 5 MHz, 20 mV rms.
5 MHz to 125 MHz, 50 mV rms.
125 MHz to 150 MHz, 100 mV rms.
150 MHz to 175 MHz, 150 mV rms.
≤5 MHz in kHz FREQuency mode.
≥5 MHz in MHz FREQuency mode.

Impedance:	1 MΩ, ≤40 pF.
Attenuator:	X1, X10 switchable.
Slope:	+, – switchable.
Trigger Level:	Preset or variable.
LP Filter:	10 kHz, nominal –3 dB cutoff frequency.
Maximum input:	200 V peak.

CHANNEL B INPUT CHARACTERISTICS

Bandwidth:	5 Hz to 2 MHz, ac coupled.
Sensitivity:	30 mV rms.
Impedance:	1 MΩ, ≤40 pF.
Attenuator:	X1, X10 switchable.
Slope:	+, – switchable.
Maximum input:	200 V peak.

TOTALIZE START/STOP INPUT

Logic Levels:	Standard TTL levels; low level inhibits totalizing, high level enables it.
Loading:	One standard TTL gate.

TIME BASE CHARACTERISTICS

Type:	Crystal controlled oscillator.
Internal Frequency:	10 MHz.
Setability:	±0.1 ppm (±1·Hz).
Line Voltage Stability:	≤1 ppm with ± 10% line voltage variation.
Temperature Stability:	≤.001% (≤10 ppm), 0°C to 50°C ambient.
Maximum aging rate:	±10 ppm/yr.
External Time Base Input:	10 MHz > 1.77 V rms.

DISPLAY CHARACTERISTICS

Visual Display:	Eight .56″ seven-segment digits with kHz/µs, MHz/ ms, GATE and OVERFLOW indicators.
OVERFLOW Indication:	LED indicator lights when count exceeds 99999999 during any selected gate time.

Display Update Time:	**kHz FREQ**uency and **CHECK** modes: user-selected gate time of .01, .1, 1, or 10 s plus fixed 200 ms interval. **MHz FREQ**uency mode: user-selected gate time of .02, .2, 2, or 20 s plus fixed 400 ms interval. **PER**iod, **RATIO**, and **TIME** Interval modes: user-selected cycles averaging of 1, 10, 100, or 1000 cycles plus fixed 200 ms interval. Continuous in **TOTAL**ize mode.

RESET & HOLD SWITCHES

RESET:	Resets the counter and display to zero.
HOLD:	Except in TOTALize mode, any measurement in progress is stopped, the counter is reset, and the last complete measurement is displayed. When HOLD is released, a new measurement begins. In the TOTALize mode, the counter is stopped but not reset, and the last count is displayed. When HOLD is released, the count continues from where the counter stopped.

GENERAL CHARACTERISTICS

Power Requirements:	100, 120, 220 or 240 VAC 10% with rear panel LINE VOLTAGE SELECT Switches, 50/60 Hz; 20 VA.
Dimensions (HxWxD):	71 x 261 x 211 mm (2.8 x 10.3 x 8.3")
Weight:	1.8 kg (3.96 lbs).
Temperature Range & Humidity	
Operation:	0°C to +50°C <80% R.H.
Storage:	-20°C to +60°C <70% R.H.

CONTROLS AND INDICATORS

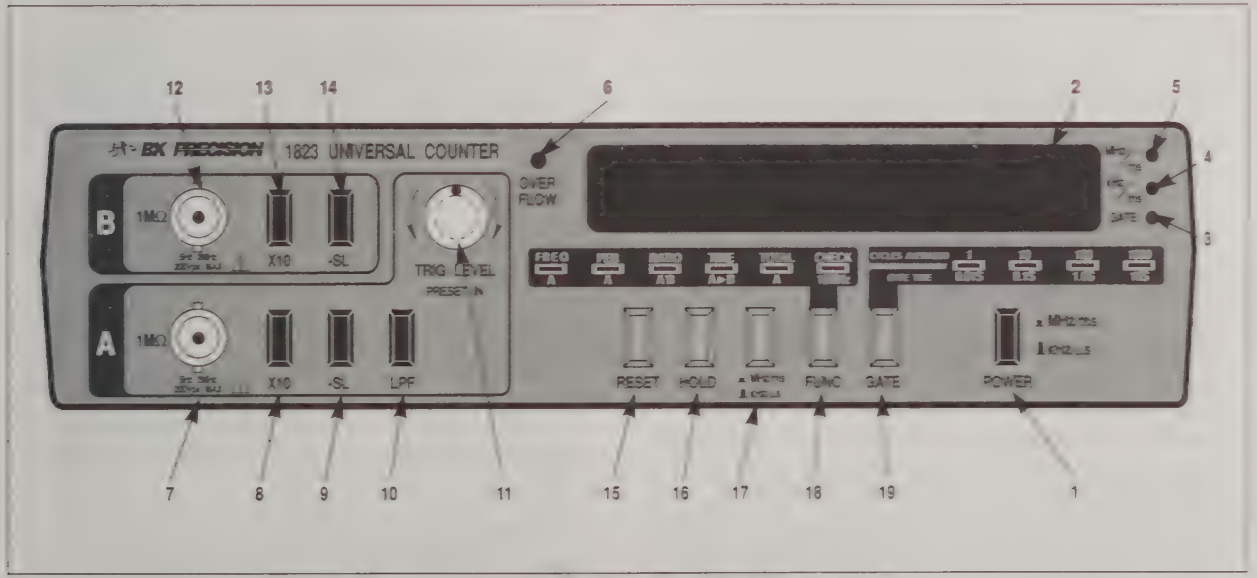

Figure 1a. Front Panel Controls And Indicators.

FRONT PANEL. Refer to Fig. 1a.

1. **POWER Switch.** Turns the unit ON and OFF.

2. **Display.** Eight-digit display used for all readings.

3. **GATE Indicator.** Lights whenever a measurement is being taken.

4. **kHz/µs Indicator**. In FREQuency A mode, indicates that the frequency displayed is in kilohertz. In PERiod A or TIME Interval A ▶ B mode, indicates that the period or time interval displayed is in microseconds. Not used in RATIO A/B or TOTALize A modes.

5. **MHz/ms Indicator.** In FREQuency A mode, indicates that the frequency displayed is in megahertz. In PERiod A or TIME Interval A ▶ B mode, indicates that the period or time interval displayed is in milliseconds. Not used in RATIO A/B or TOTALize A modes.

6. **OVERFLOW Indicator.** Lights whenever the range of the display is exceeded. One or more most significant digits are not displayed.

Items 7 through 11 apply to Channel A only.

7. **Channel A Input Jack.** Female BNC connector terminated in a 1 megohm input resistance, shunted by ≤40 pF capacitance.

8. **X10 Attenuator Switch.** When this switch is pushed in, the Channel A input is attenuated 10:1 before application to the counter. With the switch released (out), the signal is applied unattenuated.

9. **-SL (Slope) Switch.** Selects positive-going or negative-going edge of Channel A signal for triggering. When pushed in, negative-going edge is selected; when released (out), positive-going edge is selected.

10. **LPF (Low-Pass Filter) Switch.** With this switch pushed in, the Channel A input is routed through a low-pass filter with a –3 dB point of approximately 10 kHz. When it is released (out), the input is applied directly.

11. **TRIG LEVEL Control.** Adjusts trigger threshold level on the Channel A input signal. Pushing the knob in (**PRESET-IN**) sets this level at the mid-point of a symmetrical sine wave input. Pulling the knob out and rotating it varies the level from negative (–) to positive (+) around the midpoint.

Items 12 through 14 apply to Channel B only.

12. **Channel B Input Jack.** Female BNC connector terminated in a 1 megohm input resistance, shunted by ≤40 pF capacitance.

13. **X10 Attenuator Switch.** When this switch is pushed in, the Channel B input is attenuated 10:1 before application to the counter. With the switch released (out), the signal is applied unattenuated.

14. **-SL (Slope) Switch.** Selects positive-going or negative-going edge of Channel B signal for triggering. When pushed in, negative-going edge is selected; when released (out), positive-going edge is selected.

15. **RESET Switch.** In all modes, pushing this momentary switch resets the counter to zero. When it is released, the measurement starts again.

16. **HOLD Switch.** Functions as follows:

    a. All modes except TOTALize A: Setting this switch to ON "freezes" the display at the existing reading and resets the counter. Releasing the switch starts a new measurement; the display is updated when this measurement is completed.

    b. TOTALize A mode: Setting the switch to ON "freezes" the display at the existing reading and halts the totalizing process. When the switch is released, counting resumes, provided that the gating signal at the rear panel **TOTALIZE START/ STOP INPUT** jack (23) is high (or jack is open).

17. **kHz/µs - MHz/ms Switch.** When pushed in, this switch selects megahertz display for frequency readings, or millisecond display for period and time interval readings. When released (out), it selects kilohertz or microsecond display. Not used in RATIO A/B and TOTALize A modes.

18. **FUNCtion Switch.** Pushing this momentary switch selects the six counter operating modes and lights the corresponding mode indicators as follows:

    a. **FREQuency A Mode Indicator.** When selected, the unit measures the frequency of the signal at Channel A input. Readings are in kHz or MHz as selected by the **kHz**/µs - MHz/ms switch (17), and as indicated by the **kHz**/µs or **MHz/ms** indicators (4, 5). Resolution is selected by the **GATE** switch (19). This mode is automatically selected when the counter is powered ON.

    b. **PERiod A Mode Indicator.** When selected, the unit measures the period of the signal at the Channel A input. Readings are in µs or **ms** as selected by the **kHz**/µs - **MHz/ms** switch (17), and as indicated by the **kHz** **%s** or **MHz ms** indicators (4, 5). Cycles Averaged: 1, 10, 100, or 10000 are selected by the **GATE** switch (19).

    c. **RATIO A B Mode Indicator.** When selected, the unit measures the ratio of the Channel A frequency to the Channel B frequency. Cycles averaged; 1, 10, 100, or 1000 are selected by the **GATE** switch (19).

    d. **TIME Interval A ► B Mode Indicator.** When selected, the unit measures the time interval from an edge of the Channel A signal to an edge of the Channel B signal. Positive-going or negative-going edge of each signal is selected by the **-SL** switches (9, 14). Display is in µs or **ms**, as selected by the **kHz**/µs - **MHz/ms** switch (17), and as indicated by the **kHz**/µs or **MHz/ms** indicators (4, 5). Events measured; 1 (single shot), 10, 100, or 1000 is selected by the **GATE** switch (19).

    e. **TOTALize A Mode Indicator.** When selected, the unit counts cycles of the Channel A input and continuously displays that count. Totalization can be controlled by a gate signal at the rear panel **TOTALIZE START/STOP** jack (23).

    f. **CHECK Mode Indicator.** When selected, the unit displays the frequency of the internal time base, providing a general check of performance.

19. **GATE Switch.** Pushing this momentary switch selects the degree of display resolution in all modes except TOTALize A as follows;

    a. **1 / 0.01s Indicator.** When selected, the unit measures FREQuency A with a 0.01s Gate Time or PERiod A, RATIO A/B, and TIME Interval A ► B for one cycle between display updates. This Gate Time is automatically selected when the unit is powered ON.

b. **10 / 0.1s Indicator.** When selected, the unit measures FREQuency A with a 0.1s Gate Time or PERiod A, RATIO A/B, and TIME Interval A ► B for 10 cycles averaging between display updates.

c. **100 / 1s Indicator.** When selected, the unit measures FREQuency A with a 1.0s Gate Time or PERiod A, RATIO A/B, and TIME Interval A ► B for 100 cycles averaging between display updates.

d. **1000 / 10s Indicator.** When selected, the unit measures FREQuency A with a 10s Gate Time or PERiod A, RATIO A/B, and TIME Interval A ► B for 1000 cycles averaging between display updates.

NOTE:

Measuring the PERiod of low frequencies such as 10 Hz with 100 or 1000 cycles averaging will result in extremely long display update times.

REAR PANEL. Refer to Fig. 1b.

20. **Fuseholder.**

21. **Line Cord Receptacle.**

22. **LINE VOLTAGE SELECT Switches.** Combination settings allow Universal Power Operation: 100/120/220/240 VAC, 50/60 Hz.

23. **TOTALIZE START/STOP INPUT Jack.** Input jack used to control the totalization function, if desired. Unit stops totalizing whenever the signal applied at this jack goes to a TTL low level (or is connected to chassis ground).

24. **EXTERNAL TIME BASE INPUT Jack.** Input jack used to feed in a more accurate 10 MHz reference than the 10 PPM internal oscillator.

25. **TIME BASE SELECT Switch.** Used to select **EXTernal** or **INTernal** counter time base operation.

26. **OSC. ADJUST.** Used to adjust internal time base without case removal.

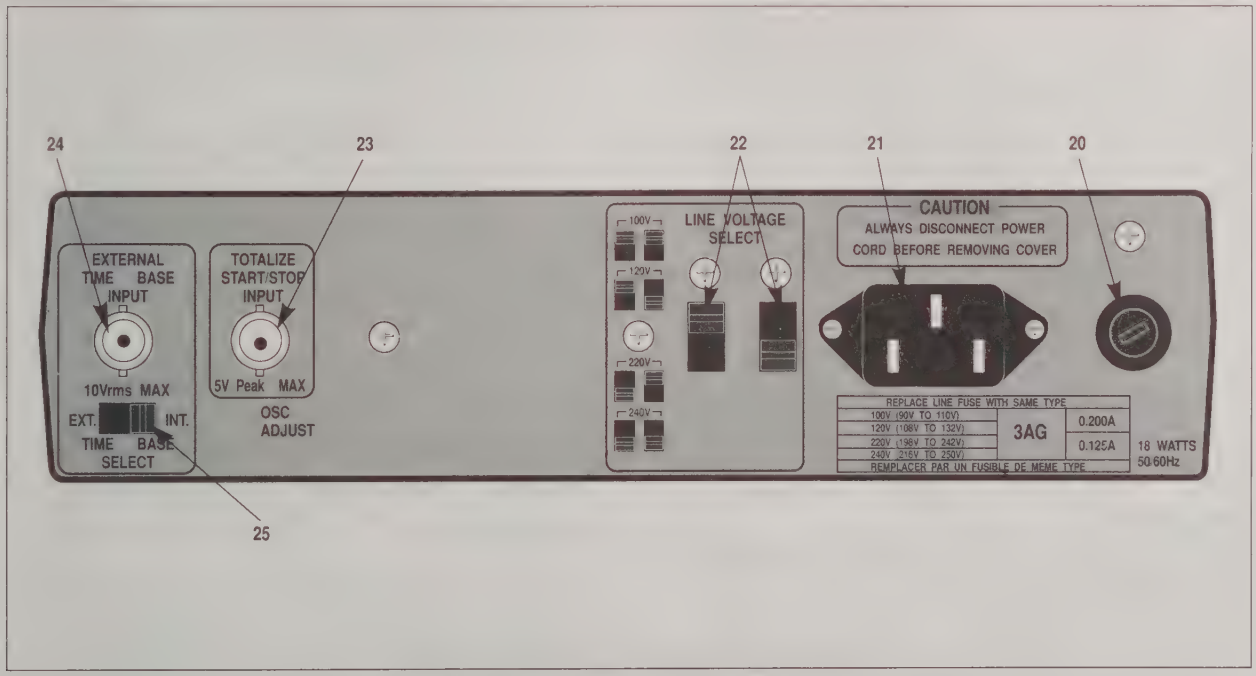

Figure 1b. Rear Panel Controls And Indicators.

OPERATING INSTRUCTIONS

SAFETY PRECAUTIONS

WARNING

Use only a polarized 3-wire ac outlet. This assures that the panels and ground points of the counter are connected to a good earth ground, and reduces danger from electrical shock.

Some operating conditions may pose an electrical shock hazard. These conditions are identified, and corresponding precautions listed, in the "TEST INSTRUMENT SAFETY" recommendations which are found starting on the inside front cover of this manual. Know and observe these precautions.

PRELIMINARY

Numbers in parentheses refer to items in "CONTROLS AND INDICATORS" section and Fig. 1.

1. Connect the unit to ac power.
2. Set the POWER switch (1) to ON (pushed in). If no other front panel buttons have been engaged, the display is blank except for the lit kHz/µs indicator (4).

CAUTION

1. *Application of input voltages higher than 200 V peak may damage the counter. Before applying any signal to the inputs, make certain that it does not exceed 200 V peak.*
2. *Engaging the X10 switches (8, 13) does NOT alter these upper limits.*
3. *Counter ground points are connnected directly to earth ground. Always connect counter ground only to ground points in the circuit under test.*

FREQUENCY MEASUREMENTS

Basic Procedure

1. Apply the signal to be measured to the Channel A input jack (7).
2. Engage the FREQuency A Mode with the FUNCtion switch (18).
3. Select measurement units with the kHz/µs-MHz/ms switch (17): in for megahertz, out for kilohertz. The kHz/µs or MHz/ms indicator (4, 5) lights accordingly.

NOTE

Guaranteed frequency measurement ranges are as follows:

kHz mode: 5 Hz to 10 MHz (above 10 MHz, display may show zero with no OVERFLOW indication); sine wave sensitivity: 20 mV rms, 5 Hz to 5 MHz.

MHz mode: 50 kHz to 175 MHz; sine wave sensitivity:
50 mV rms, 50 kHz to 125 MHz.
100 mV rms, 125 MHz to 150 MHz.
150 mV rms, 150 MHz to 175 MHz.

Because of these limits, try both ranges for an unknown circuit point unless you are reasonably sure of its frequency.

4. Select the degree of resolution desired, using the GATE switch (19).

5. Frequency is given by the display (2). The GATE indicator (3) lights while each measurement is in progress, and the display is updated at the end of each measurement interval.

NOTE

Some measurement delay and display instability may be encountered; see "Display Interpretation".

6. The OVERFLOW indicator (6) lights whenever the range of the display is exceeded.

7. Engaging the HOLD switch (16) "freezes" the display at the existing reading. When HOLD is released, a new measurement begins (GATE indicator lights), but the display continues to hold the old reading until the new measurement is completed.

8. Pushing the RESET switch (15) resets the display to zero. When RESET is released, a new measurement begins (GATE indicator lights), but the display remains at zero until the new measurement is complete.

Input Controls

The following controls can be used as required to condition the input, to prevent mis-counting from input noise or ringing.

1. **Input Filter.** Engaging the LPF (Low Pass Filter) switch (10) routes the Channel A input through a low-pass filter (–3 dB frequency of approximately 10 kHz) before application to the counter. This helps eliminate counting errors in low frequency measurements by reducing effects of high-frequency noise.

2. **Input Attenuator.** Engaging the Channel A X10 switch (8) attenuates the Channel A signal approximately 10:1 before application to the counter. This helps prevent mis-counting caused by noisy or improperly terminated high-amplitude signals.

3. **Slope Selection.** The Channel A -SL (Slope) switch (9) selects positive or negative edge of the Channel A signal for triggering. Pushing the switch in triggers the unit on the negative-going edge; leaving it out causes triggering on the positive-going edge.

NOTE

The Channel A -SL switch is bypassed whenever FREQuency MHz mode is selected. Unit then counts on negative slope.

4. **Trigger Level Adjustment.** Channel A trigger threshold can be varied by the TRIG LEVEL control (11) as follows:
   a. Pushing the control in (PRESET-IN) fixes the trigger level at roughly the average value of the Channel A input signal.
   b. Pulling the control out and rotating it varies the threshold level from negative (–) to positive (+) around the PRESET-IN level.

The TRIG LEVEL control is discussed in more detail in the "General Considerations".

PERIOD MEASUREMENTS

In PERiod A mode, the unit displays the period, or time required for one cycle of the input signal to occur. The actual measurement is made by averaging over 1, 10, 100, or 1000 cycles.

Basic Procedure

1. Apply the signal to be measured to the Channel A input jack (7).
2. Engage the PERiod A Mode with the FUNCtion switch (18).
3. Select measurement units with the kHz/µs-MHz/ms switch (17): in for milliseconds, out for microseconds. The kHz/µs or MHz/ms indicator (4, 5) lights accordingly.
4. Select the degree of resolution desired, using the GATE switch (19).

   (The GATE switch determines how many cycles are averaged in the measurement: 1, 10, 100, or 1000.)

NOTE

The GATE switch in the 1000/10s position is not used in ms mode (kHz/µs-MHz/ms switch pushed in). Engaging this switch causes a display of all "eights" and decimal points to appear and the OVERFLOW indicator to light.

5. Period is given by the display (2). The GATE indicator (3) lights while each measurement is in progress, and the display is updated at the end of each measurement interval. (At higher frequencies, the GATE indicator may flash too quickly to be seen.)

NOTE

Some measurement delay and display instability may be encountered; see "Display Interpretation".

6. The OVERFLOW indicator (6) lights whenever the range of the display is exceeded.
7. Engaging the HOLD switch (16) "freezes" the display at the existing reading. When HOLD is released, a new measurement begins (GATE indicator lights), but the display continues to hold the old reading until the new measurement is completed.
8. Pushing the RESET switch (15) resets the display to zero. When RESET is released, a new measurement begins (GATE indicator lights), but the display remains at zero until the new measurement is complete.

9. The Channel A input controls (filter, attenuator, trigger slope and level) may be used to condition the input, to prevent mis-counting from input noise or ringing. See "Frequency Measurements - Input Controls".

FREQUENCY RATIO MEASUREMENTS

In this mode of operation, the counter displays the ratio of the frequency applied to Channel A to the frequency applied to Channel B. The Channel A frequency should preferably be equal to or greater than that of Channel B, and both frequencies must be within the limits given in the "SPECIFICATIONS" section.

Frequency ratio is determined by counting the number of Channel A cycles occurring during a specified number of Channel B cycles (1, 10, 100, or 1000) and applying the result, with a proper decimal point, to the display.

Basic Procedure

1. Connect the signals to be measured to the Channel A and Channel B input jacks (7, 12).

NOTE

Both channels may be connected to the same signal for a ratio of 1.

2. Engage the RATIO A/B Mode with the FUNCtion switch (18).

3. Both the kHz/µs and MHz/ms indicators (4, 5) are off because the reading displayed is a ratio.

4. Select the resolution desired using the GATE switch (19).

(The GATE switch determines over how many cycles of Channel B the measurement is taken: 1, 10, 100, or 1000.)

NOTE

The kHz/µs-MHz/ms switch (17) is ignored in RATIO A/B mode.

5. Frequency ratio is given by the display (2). The GATE indicator (3) lights while each measurement is in progress, and the display is updated at the end of each measurement interval. (At higher Channel B frequencies, the GATE indicator may flash too quickly to be seen.)

NOTE

Some measurement delay and display instability may be encountered; see "Display Interpretation".

6. The OVERFLOW indicator (6) lights whenever the range of the display is exceeded.

7. Engaging the HOLD switch (16) "freezes" the display at the existing reading. When HOLD is released, a new measurement begins (GATE indicator lights), but the display continues to hold the old reading until the new measurement is completed.

8. Pushing the RESET switch (15) resets the display to zero. When RESET is released, a new measurement begins (GATE indicator lights), but the display remains at zero until the new measurement is complete.

9. The Channel A input controls (filter, attenuator, trigger slope and level) may be used to condition the inputs, to prevent mis-counting from input noise or ringing. See "Frequency Measurements - Input Controls". Channel B input controls are also provided; x10 attenuator (13), and -SL selector (14), and operate identically to their Channel A counterparts.

TIME INTERVAL MEASUREMENTS

In Time Interval mode, the unit measures the elapsed time from a selected edge of the Channel A waveform to a selected edge of the Channel B waveform.

For a stable reading, the two input signals should be related to each other such that this time interval remains reasonably constant from one measurement to the next. For example, two digital waveforms derived from the same clock would be suitable; two arbitrary frequencies from separate function generators would not.

Both inputs may be connected to the same signal for duty cycle measurements; this is discussed in the "General Considerations".

Basic Procedure

1. Connect the signals to be measured to the Channel A and Channel B input jacks (7, 12).

2. Engage the TIME Interval A ▶ B Mode with the FUNCtion switch (18). The mode label serves as a reminder that the measurement starts at the Channel A edge and stops at the Channel B edge.

3. Select desired edge of each waveform using the Channel A and Channel B -SL switches (9, 14). Push switch in for negative-going edge, leave out for positive-going edge.

NOTE

When measuring time interval between similar edges on the same waveform (e.g. positive edge to next positive edge), it is advisable to use PERiod rather than Time Interval mode. See "General Considerations".

4. Set the Channel A TRIG LEVEL control (11) to PRESET-IN (pushed in). This ensures that both Channel A and Channel B are triggering at the same level (approximately the average) on their respective waveforms.

5. Select measurement units with the kHz/µs-MHz/ms switch (17): in for milliseconds, out for microseconds. The kHz/µs or MHz/ms indicator (4, 5) lights accordingly.

6. Select the degree of resolution desired, using the Gate switch (19).

NOTE

Selecting a finer TIME Interval resolution results in more periods being averaged (1, 10, 100, 1000), and a greater accumulated error. The result is that all GATE settings have the same inherent resolution (see "Display Interpretation - Display Instability").

NOTE

The GATE switch in the 1000/10s position is not used in ms mode (kHz/µs-MHz/ms switch pushed in). Engaging this switch causes a display of all "eights" and decimal points to appear and the OVERFLOW indicator to light.

7. Time interval is given by the display (2). The GATE indicator (3) lights while each measurement is in progress, and the display is updated at the end of each measurement interval. (At higher frequencies, the GATE indicator may flash too quickly to be seen.)

NOTE

Some measurement delay and display instability may be encountered; see "Display Interpretation".

8. The OVERFLOW indicator (6) lights whenever the range of the display is exceeded.

9. Engaging the HOLD switch (16) "freezes" the display at the existing reading. When HOLD is released, a new measurement begins (GATE indicator lights), but the display continues to hold the old reading until the new measurement is completed.

10. Pushing the RESET switch (15) resets the display to zero. When RESET is released, a new measurement begins (GATE indicator lights), but the display remains at zero until the new measurement is complete.

11. Time interval can also be measured for "once-only" events. Select the 1 0.01s position with the GATE switch (19) (this must be used for single events, because the others are all multiple-event averaging). Set the -SL switches for the anticipated level transitions, and push RESET to prime the unit. When the event has occurred (Channel A transition followed by Channel B transition), the time interval is displayed. For each single-event measurement, the counter must again be primed by pressing RESET.

Input Controls

The following controls can be used to condition the input, to prevent mis-counting from input noise or ringing.

1. **Input Filter.** Engaging the LPF (Low Pass Filter) switch (10) routes the Channel A input through a low-pass filter (−3 dB frequency of approximately 10 kHz) before application to the counter. This helps eliminate the effects of high-frequency noise in the Channel A input.

2. **Input Attenuator.** Engaging the Channel A or Channel B X10 switch (8, 13) attenuates the Channel A or Channel B signal approximately 10:1 before application to the counter. This helps prevent mis-counting caused by noisy or improperly terminated high-amplitude signals.

TOTALIZE MEASUREMENTS

The TOTALize A mode is used to count the total number of events occurring during a specific time period. This time period can be defined by front panel switch action, or, for better accuracy, by a gating signal applied to the rear panel. Events should occur at least five times per second for accurate counting.

1. Engage the TOTALize A Mode with the FUNCtion switch (18). GATE (19) and kHz/µs-MHz/ms (17) settings are ignored.

2. If the counting is to be controlled electronically, connect the gating signal to the rear panel TOTALIZE START/STOP jack (23). A TTL high at this input enables the totalizing process; a TTL low disables it, holding the display at the accumulated value. If no signal is connected, the jack is pulled high internally so counting occurs.

3. Depress the RESET switch (15) to zero the counter. If no gating signal is connected to the TOTALIZE START/ STOP jack (23), the unit starts counting as soon as the RESET switch is released. If a gating signal is connected, counting starts when RESET is released and the gating signal goes high.

4. As the unit totalizes, it displays the count continually. Maximum count is 99,999,999. If this is exceeded, the OVERFLOW indicator (6) lights, and the count continues.

5. Counting is halted by one of three methods:
   a. If the gating signal at the TOTALIZE START/STOP jack goes low, counting stops and the display is held at the accumulated total. Counting resumes when the gating signal again goes high.
   b. If the HOLD switch (16) is engaged, counting stops and the display is held at the accumulated total. Counting resumes when the switch is released.
   c. Pressing RESET at any time clears the counter and resets the display to zero.

NOTE

The gating signal at the TOTALIZE START/STOP jack halts totalization by inhibiting the Channel A input signal. It also blocks this signal in all other operating modes except FREQuency MHz. This should be kept in mind if the jack remains connected during other measurements.

6. The Channel A input controls (filter, attenuator, trigger slope and level) may be used to condition the input, to prevent mis-counting from input noise or ringing. See "Frequency Measurements - Input Controls".

USE OF EXTERNAL TIME BASE INPUT

The "rule of thumb" for a calibration or measurement standard is that it should be at least 5 to 10 times better than the equipment being calibrated. The Internal Time Base Oscillator Accufacy of the Model 1823 counter is ±10 ppm (10×10^{-6}) from 0°C to 50°C, see "SPECIFICATIONS". This is more than adequate for most audio applications, the maximum display error for frequencies from 5 Hz thru 10 kHz is ONLY ±1 Hz using the 1.0s gate. For RF frequencies above 1 MHz, the time base may introduce an error proportional to the frequency

being measured. For Example, the *maximum* display error for the ±10 ppm internal time base with the gate time selected to give 1 Hz resolution would be:

Frequency	Display Error
10 kHz	1 Hz (±1 LSD)
100 kHz	1 Hz + 1 Hz (±1 LSD)
1 MHz	10 Hz + 1 Hz (±1 LSD)
10 MHz	100 Hz + 1 Hz (±1 LSD)
100 MHz	1000 Hz + 1 Hz (±1 LSD)
175 MHz	1750 Hz + 1 Hz (±1 LSD)

Most RF "Low Power" applications require a frequency tolerance of 50 ppm to 200 ppm, the Model 1823 is adequate for use in servicing these applications. Some RF "High Power" applications have frequency tolerances of 20 ppm or lower; Broadcast Television with Power greater than 50 Watts have a maximum frequency tolerance of only 1000 Hz.

The Model 1823 may be used in conjunction with a more accurate **EXTERNAL** standard 10 MHz Time Base Oscillator; 1 ppm quartz crystal TCXO, Cesium or rubidium references, or a LORAN-C frequency standard to service any application requiring a 20 ppm or lower tolerance.

The procedure for using the EXTERNAL TIME BASE INPUT follows (refer to fig.2.b):

1. Connect the external 10 MHz frequency reference with a output voltage level between 1.77 V and 10 V rms (Standard TTL) to the EXTERNAL TIME BASE INPUT jack (24) located on the rear panel.
2. Set the TIME BASE SELECT switch (25) to EXT, the counter is now ready to use the more accurate standard.

DISPLAY INTERPRETATION

Display Formats

Sample displays are given in Fig. 2. In Fig. 2a, a value of 1234.567 is displayed, and the kHz/µs indicator is lit. This may represent either a frequency, period, or time interval reading; a glance at the FUNCtion mode indicator shows which is correct.

Assuming that Fig. 2a represents a frequency reading, the resolution displayed is .001 kHz, or 1 Hz. If the kHz/µs-MHz/ms switch is now pushed in, leaving all else unchanged, the display changes to that of Fig. 2b. This is the same frequency as in Fig. 2a, but given in megahertz. Note that the resolution is now .00001 MHz, or 10 Hz, even though a different GATE Time was not selected.

If the display of Fig. 2a is a period or time interval, depressing the kHz/µs-MHz/ms switch changes the display to 1.234567 ms. Unlike the frequency example, no change in resolution occurs (resolution = .001 µs = .000001 ms), merely a change of measurement units (decimal point shifts three places to left).

Fig. 2c shows a frequency ratio display obtained by connecting both inputs to the same signal and using the same GATE setting as in a or b. Neither units indicator is lit, since the reading displayed is a ratio.

Fig. 2d gives a typical totalize display. Totalizations have no units, and are always integers (no digits to right of decimal point). At higher

totalizing frequencies, the least significant display digits tend to fade due to their rapid rate of change.

Display Instability

An uncertainty of ±1 least significant digit is inherent in all digital measurements. However, greater display uncertainties can result from other factors, as follows:

Noise or ringing on the inputs can cause false triggering. In some cases the display may be unstable, whereas in others it may appear stable but at an incorrect reading. The input controls provided on this unit can help to achieve stable triggering from noisy inputs.

Uncertainty may be introduced by instability of the input frequency. This is common with LC oscillators; crystal-controlled oscillators are much more stable.

In period, time interval, and ratio measurements, uncertainty is introduced by trigger error (see "SPECIFICATIONS"). In period and ratio, this uncertainty can be reduced by taking the measurement over a greater number of cycles. In time interval, however, multi-cycle measurements are subject to a possible error of 1 count per interval. This cumulative error is increased by measuring over a greater number of intervals. The result is that all GATE settings have the same inherent resolution, and displaying more digits results in more digits being subject to jitter.

Period and frequency are reciprocals of each other. At low frequencies, more digits can be obtained (lessening the effects of instability) using PERiod mode. Similarly, high frequency accuracy is enhanced by using FREQuency mode. The "crossover" point between the two modes is 10 kHz. The APPENDIX lists a number of common frequencies with their corresponding periods.

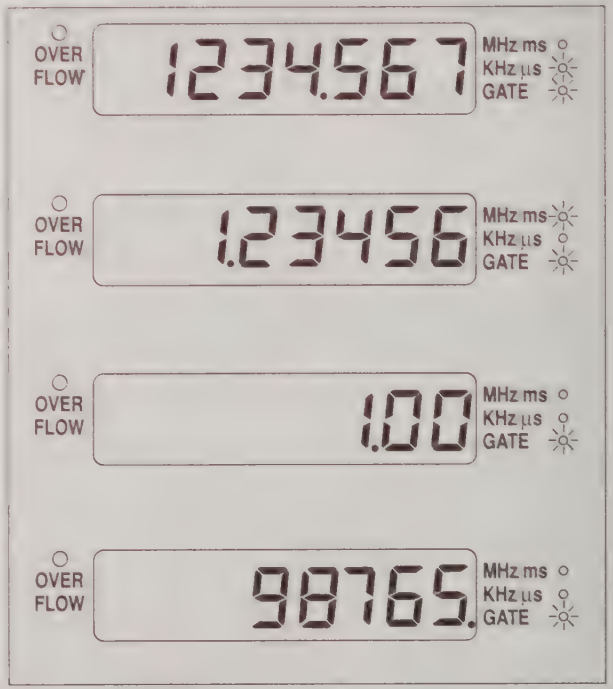

Figure 2. Samples Of Various Displays.

Measurement Delays

In all measurements (except TOTALize), the display is updated at the end of a finite measurement interval, which varies in length according to operating mode and resolution selected. For some conditions, the delay can become significant. This should be kept in mind when changing resolution or operating mode, or when using HOLD or RESET, because each of these actions initiates a new measurement. Measurement delays for each mode are discussed here.

Frequency

In frequency measurements, each GATE setting establishes a set "gate time" during which the measurement is made (GATE indicator lights during this interval). Gate times for kHz and MHz modes are as follows:

Mode	GATE Time Setting	Actual GATE Time	Display Resolution
kHz	0.01s	0.01s	100 Hz
kHz	0.1s	0.1s	10 Hz
kHz	1.0s	1.0s	1 Hz
kHz	10s	10s	0.1 Hz
MHz	0.01s	0.02s	1 kHz
MHz	0.1s	0.2s	100 Hz
MHz	1.0s	2.0s	10 Hz
MHz	10s	20s	1 Hz

As observed in the table, smaller GATE times result in lower resolutions. They are useful when quicker updates are desired, for example, while tuning an oscillator. Better resolutions require longer update intervals.

Period/Time Interval

Period and time interval measurements are made by timing a preset number of cycles of the input. The number is determined by the GATE switch as follows:

Mode	CYCLES AVERAGED Setting	Display Resolution
µs	1	0.1 µs
µs	10	0.01 µs
µs	100	0.001 µs
µs	1000	0.0001 µs
ms	1	0.0001 ms
ms	10	0.00001 ms
ms	100	0.000001 ms

The time required for a period or time interval measurement to be completed can be found by the formula:

$$\text{Time} = \left(\begin{array}{c}\text{Number of}\\ \text{cycles (intervals)}\\ \text{averaged}\end{array}\right) \times \left(\begin{array}{c}\text{Average}\\ \text{cycle (interval)}\\ \text{length}\end{array}\right)$$

where time units are same (seconds, milliseconds, etc.) as the desired result.

For period measurements this is also:

$$\text{Time} = \frac{\text{Number of cycles averaged}}{\text{Input frequency (Hz)}}$$

Note that the GATE switch selects 100 and 1000 cycle averaging. Because of this, significant delays may occur between display updates at low frequencies.

Frequency Ratio

To determine frequency ratio, the unit applies the input signals to two separate counters. Each counts cycles of its input until the Channel B counter reaches a specified number. Both counters then stop and the number left in the Channel A counter is applied to the display, with a proper decimal point, as the ratio.

Measurement delays are dependent on the frequency of the Channel B input and the particular resolution selected. The time required for a ratio measurement to be completed can be found by the formula:

$$\text{Time (seconds)} = \frac{\text{Channel B reference}}{\text{Input frequency (Hz)}}$$

Note that the GATE switch selects 100 and 1000 as Channel B reference. Because of this, noticeable delays may occur between display updates at low Channel B frequencies. The Channel A frequency does not affect measurement time in ratio measurements.

Inter-Measurement Interval

The time interval between measurements (GATE indicator off) is fixed at 200 milliseconds in all modes except FREQuency MHz, where it is 400 milliseconds, and TOTALize, in which counting is continuous. This fixed interval is independent of gate time, number of cycles, or input frequency.

GENERAL CONSIDERATIONS

Use of Attenuator Probes

Input resistance (1 MΩ) and input capacitance (≤40 pF max) are independent of the X10 switches. To decrease loading, a high-impedance oscilloscope probe such as the following may be used:

1. **B&K-Precision** Model PR-37 10:1 and 1:1 compensated oscilloscope probe.

2. **B&K-Precision** Model PR-46 10:1 compensated oscilloscope probe.

The loading effect of the PR-37 is 10 MΩ and 12.5 pF in the X10 mode, and 1 MΩ and 80 pF in the X1 mode. Use the probe in the X10 position whenever possible for less circuit loading. The X1 mode also has reduced frequency bandwidth that could be unacceptable for high frequency signals.

NOTE

When using a 10:1 probe such as listed above, make certain that the signal amplitude is large enough to provide at least the minimum required signal to the counter after probe attenuation (see "Sensitivity" in "SPECIFICATIONS").

Mode or Resolution Changes

When switching resolution or operating mode, note that such a change initiates a new measurement; the display is not updated until the new measurement is completed. Even though the decimal point and leading zeroes are adjusted immediately, appearance of the correct value may be significantly delayed depending on measurement interval (see "Display Interpretation—Measurement Delays").

Standing Waves

Standing waves are usually present on a transmission line not terminated in its characteristic impedance. These standing waves may cause damage to the signal source or produce inaccurate measurements. Therefore, when measuring radio frequencies, the transmission line characteristic impedance and the terminating impedance should each match the source impedance. For example, for a source impedance of 50 ohms, use 50 ohm coaxial cable terminated with a 50 ohm resistive load. Use a dc blocking capacitor in situations where bias voltage or other dc voltages could be affected by the termination resistor.

If additional cable is required, note that the increased cable length results in increased shunt capacitance. In addition, the effect of standing waves becomes more pronounced as the cable length approaches one-quarter wavelength of the frequency being measured. This is especially true if the cable is not terminated in its characteristic impedance. Therefore, to keep shunt capacitance and standing waves within tolerable limits, it is recommended that for radio frequency measurements, the cable be no longer than three feet (90 cm).

Duty Cycle Measurements

Time Interval mode can be used to determine the duty cycle of a digital waveform, by applying the same signal to Channel A and Channel B, and selecting proper edges for triggering.

For example, refer to Fig. 3. The duty cycle, or ratio of on-time to total period, is found by selecting positive slope for Channel A (so measurement starts at beginning of T1) and negative slope for Channel B (measurement finishes at end of T1). After this reading is taken, the period is measured, (preferably by using PERiod mode; see next paragraph), and the duty cycle is obtained as follows:

$$\text{Duty cycle} = \frac{T1}{\text{PERIOD}} \times 100\%$$

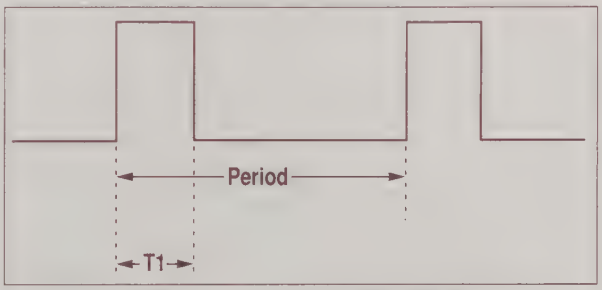

Figure 3. Duty Cycle Measurement.

PERiod vs. TIME Interval Mode

When measuring time interval between similar edges on the same waveform (e.g. positive edge to next positive edge), it is advisable to use PERiod rather than Time Interval mode, because of the following:

1. In TIME Interval mode, the unit may tend to both trigger and stop on the same edge, resulting in erroneous readings. Waveforms with fast rise times (such as TTL signals) are less prone to this phenomenon than those with less steep slopes, such as sine and triangle waves.

2. PERiod mode affords better accuracy, especially at higher number of cycles averaged. In TIME Interval mode, the possibility of error increases with number of intervals averaged (1, 10, 100, 1000) so that more digits tend to jitter as more are selected. No actual improvement in accuracy is gained. In PERiod mode the possibility of error is constant for any number of cycles averaged.

Use of TRIG LEVEL Control

When pushed in (PRESET-IN), this control sets the trigger threshold to the approximate average of the Channel A signal. While this is sufficient for many signals, it would not be adequate for the waveform of Fig. 4. The lower dotted line represents the trigger level set by the PRESET-IN position. This level, the average of the pulse train, is close to the level of noise present, and false triggering could occur.

By pulling the TRIG LEVEL control out and rotating it, the trigger threshold can be varied above (+) or below (-) the average. In the figure, an appropriate threshold setting would be somewhat above the noise level, as shown by the upper dotted line.

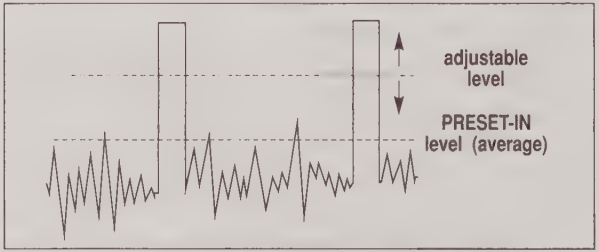

Figure 4. Example Of Trigger Level Variation.

Line Frequency Measurement

WARNING

Use caution in measuring the line frequency of an ac outlet. Using the probe tip only, measure both sides of the line. The ground side will give a zero reading and the hot side will provide the desired measurement. Do not use the "ground" lead of the probe. Remember that the chassis and circuit ground of the frequency counter and the "ground" lead of the probe are already at earth ground (via the 3-wire power cord of the instrument). Touching the "ground" lead to the "hot" side of the line would place a direct short on the power line through the probe cable, resulting in possible injury and damage to the probe cable.

Use of the attenuator and/or filter is advisable when measuring line frequency, since noise is usually present and can cause mis-counting.

CHECK

The CHECK mode provides a quick, general self test of instrument operation.

1. Engage the CHECK Mode with the FUNCtion switch (18). This connects the counter input internally to the time base oscillator.

2. With the kHz/µs-MHz/ms switch (17) in the kHz/µs position (out), engage each GATE Time Mode with the GATE switch (19) and check that results match the following:

GATE setting[1]	Display reads
0.01s	10000.0 kHz
0.1s	10000.00 kHz
1.0s	10000.000 kHz
10s	0000.0000 kHz, OVERFLOW lit

[1]GATE indicator lights during this interval; Time between measurements is 200 ms.

3. Set the kHz/µs-MHz/ms switch to MHz/ms (pushed in) and engage each of the three GATE Time Modes with the GATE switch (19) listed below, checking for correct results:

GATE setting[1]	Display reads
0.01s	10.0000 MHz
0.1s	10.00000 MHz
1.0s	10.000000 MHz

[1]GATE indicator lights during this interval; time between measurements is 200 ms.

4. With the kHz/µs-MHz/ms switch still set to MHz/ms, engage the 10s Mode with the GATE switch. The display should read "8 8.8.8.8.8.8.8.", with the MHz/ms and OVERFLOW indicators lit, and the GATE indicator on for 10 second intervals.

5. For any setting in either of the above two tables, pressing HOLD should hold the display value and keep the GATE indicator off for as long as the button is pushed in. When HOLD is disengaged, GATE should resume flashing. (If a new GATE Time has been selected, the display is updated to its proper value after the first GATE interval).

6. For any setting in either of the two above tables, pressing RESET should clear the display. The GATE indicator should stay off as long as RESET is pushed. Upon release of the button, GATE should resume flashing and the display should be updated at the end of the first GATE interval.

CIRCUIT DESCRIPTION

BLOCK DIAGRAM ANALYSIS

Refer to the block diagram of Fig. 5 for an overall view of circuit operation. The unit can be divided into logical groupings as shown.

Analog Input Circuits

These circuits process the analog input signals in preparation for the digital circuits which follow. Input buffers provide the high impedance desired, and also selectable X10 input attenuators. The Channel A signal is passed through a selectable low-pass filter and a preamplifier which increases sensitivity and provides selectable preset or adjustable trigger level control. Signals from both channels are squared by amplifier/Schmitt trigger circuits, so that digital waveforms of appropriate levels are obtained.

Digital Input Circuits

These circuits process the now-digital signals before they reach the counter circuits.

The Channel A signal follows two different paths, according to front panel switch settings. In one case, it is applied to a divide-by-twenty prescaler which increases the frequency range of the unit. The other path channels it to a slope selector, which chooses either the signal or its complement (the Channel B signal encounters a similar circuit), and a gating circuit which either passes or blocks it in response to a control input and a switch. This Channel A signal is then applied, together with Channel B, to the Time Interval priming circuit which passes both signals unchanged (except for special instances in Time Interval mode).

The two Channel A paths converge in a selection circuit which chooses either the original frequency or the divided-down version, in accordance with operating mode selected. This signal and that from Channel B are applied to the counter circuits.

Counter Circuits

These center around an ICM7226A Universal Counter integrated circuit, which performs all counting functions. Four control signals to the chip determine operating mode and other factors. They themselves are derived as feedback from the chip's own digit strobes (which are used as multiplex signals for the display); the feedback is selected by the front panel switches via the control logic.

Power Supply

The power supply provides regulated voltages as shown. The tapped, dual-primary transformer is universal, and can be rewired as needed for various line voltages.

SCHEMATIC DIAGRAM ANALYSIS

This discussion can best be followed by referring to the separately supplied schematic diagrams, and to the accompanying figures when directed by the text. The discussion is separated into major sections corresponding to those depicted in the main block diagram of Fig. 5.

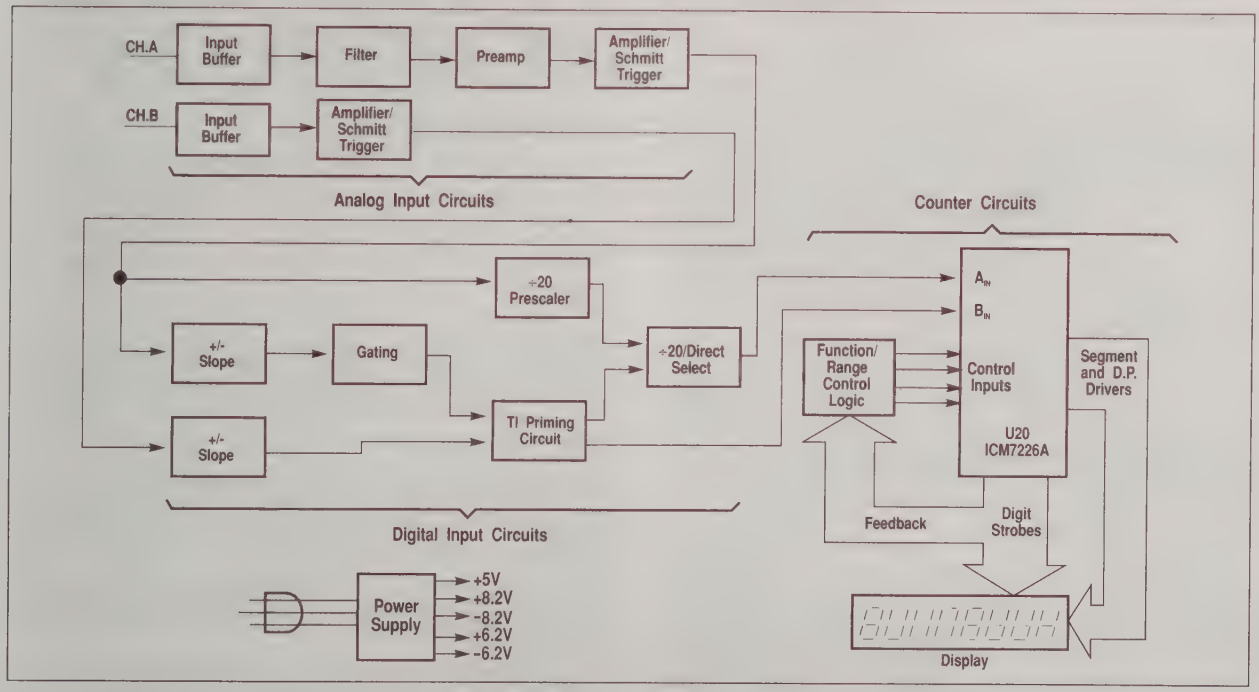

Figure 5. Block Diagram.

Analog Input Circuits

Channel A Input Buffer

Refer to the schematic diagram. The input signal is capacitively coupled via C101 to the divider of R102 and R103. X10 ATTEN. switch S7 selects either the full voltage across the divider or only the portion across R103 (approximately one tenth of the full amount). The signal is level-clamped to a maximum of ±1.4 volts by transistors Q101,102,Q117,Q118; it is then applied to the high-impedance buffer stage consisting of Q103, used as a source follower, and Q104, which serves as a current sink and enhances response to negative signal excursions. Transistor Q105 is used as a current source for successive stages.

Channel A Filter

The signal is applied to the low-pass filter consisting of R112, R113, and C116, whose values set a -3 dB point of approximately 10 kHz. When FILTER switch S9 is pushed in (ON position on schematic), diodes D106 and D107 are biased on. This provides an ac path to ground through D107, and the filter action of R112, R113, and C116 is enabled. When S9 is released, D106 and D107 are off, isolating C116 from ground, and disabling the filter action.

Channel A Pre-amplifier

The differential amplifier of transistor array IC101 compares the input signal to a variable dc level from the TRIG LEVEL control, R124. When TRIG LEVEL is pushed in (PRESET-IN), S13 is closed, bringing the amplifier input at IC101 pin 4 to approximately ground potential. The other input, at pin 1, is taken from the output of the filter. This signal, capacitively coupled at the counter input by C101, experiences no dc offset in the buffer or filter stages. Therefore, when applied to pin 1 of IC101, its average level remains near ground potential. As a result, when TRIG LEVEL is set to PRESET-IN, the quiescent level of the diff amp is set at approximately the average level of the input. When TRIG LEVEL is pulled out, S13 is opened, and the pin 4 input level is controlled by R124, which varies the quiescent level above or below the input average.

Channel A Amplifier/Schmitt Trigger

This stage (IC102) amplifies and shapes the input to ultimately produce a digital waveform which is suitable for use in the counting circuits. The circuit makes use of a 10216 ECL triple line receiver for good response throughout the frequency range of the instrument. Two of the amps in this IC (first and third on schematic) are used to square up the signal, and a third (second on schematic) is used as a Schmitt trigger.

The chip supplies a voltage reference of 3.8 volts at pin 11; this is applied through divider R129/R130/R148 and R128 to the inputs of the first amp (pins 9 and 10). A quiescent voltage difference of approximately 5 millivolts results between the two inputs. This defines the minimum amount of signal required at these inputs for proper "squaring" to occur.

The second amp, at pins 4 and 5, is used as a Schmitt trigger to eliminate false triggering caused by noise. Its trigger threshold is obtained from the first amp pin 7 output through R133. The amount of hysteresis, which provides the noise margin, is set by R134.

The third amp, at pins 12 and 13, is used to provide further "squaring" of the waveform. Inputs to this amp are the complementary outputs of the Schmitt trigger.

Transistors Q106 and Q107 are used as ECL-to-TTL level shifters. The waveform obtained across R141 is a 0 to 3.2 volt square wave with the same polarity as the input signal.

Channel B Input Buffer

The Channel B input signal is capacitively coupled via C140 to the divider of R151 and R152. X10 ATTEN. switch S10 selects either the full voltage across the divider or only the portion across R152 (approximately one tenth of the full amount). The signal is level-clamped to a maximum of 1.4 volts by transistors Q110, Q111, Q118, Q119 and applied to the high-impedance buffer stage. This consists of FET Q112, which provides high input impedance and unity gain, and Q113, which serves as a current source for successive stages.

Channel B Amplifier/Schmitt Trigger

This stage (IC105) operates in a similar manner to its Channel A counterpart (IC102), to square the waveform for use in the counter circuits. As in Channel A, a 10116 ECL triple line receiver (IC105) is used. The first amp shown on the schematic is used for squaring, and the second and third serve as Schmitt triggers.

A reference voltage of approximately 2.7V is generated from the 5V supply through the divider R174/175 and applied to one of the inputs of the first amp (pin 9), while the other input (pin 10) is directly connected to the output of the buffer. The Sensitivity adjustment setting of R175 defines the minimum squaring level (about 5 mV). The complementary outputs are applied to the second amp at pins 4 and 5 for further squaring/Schmitt triggering of the waveform. The Schmitt trigger at pins 12 and 13 provides a noise margin; its trigger threshold is obtained from the pin 11 reference via R168, and R169 determines the amount of hysteresis.

Transistors Q114 and Q115 are the ECL-to-TTL level shifters. The R172 waveform is a 0 - 2.6 volt square wave with the same polarity as the input.

Digital Input Circuits

Channel A Signal Gating

The Channel A signal from the ECL-to-TTL level shifters (across R141) is AND'ed in U15C (pins 9, 10, 11) with the output of the HOLD flip-flop (U1B/U1C and HOLD switch S2) and the voltage from the TOTALIZE START/STOP jack on the rear panel. This permits the input to be gated, either manually or electronically, during the TOTALize mode. When no control signal is connected to the TOTALIZE START/STOP jack, the jack is pulled high by R27.

Channel A/Channel B Slope Select

Positive or negative trigger slope is selected by applying the inputs through EXCLUSIVE-OR gates U18D and U18C; U18D pins 11-13 for Channel A and U18C pins 8-10 for Channel B. The other input to each gate is set either high or low by the -SL (slope) switch. The result is that either the signal or its complement is fed through to U20.

Time Interval Priming Circuit

Before any Time Interval measurement, U20 must be primed by a high-to-low transition of Channel A input, followed by a similar transition of Channel B input. In cases of repetitive input waveforms, the chip is automatically primed. However, for instances where one (and only one) time interval is to be measured, a priming circuit is used.

The circuit consists of NAND gates U1A/U1D, U8A/U8B/U8D, and EXCLUSIVE-OR gates U18A/U18B, and RESET switch S1. The input signals are fed through the XOR's. Most of the time the other XOR inputs (from the priming circuit) are low, and the XOR outputs follow the inputs.

However, when preparing to time a single event, A and B inputs are a stable high (because the inputs should be stable in anticipation of the event). Pressing RESET takes U18B pin 4 high also (only, however, if

TIME mode is selected, enabling NAND gate U1D pin 13). This produces a low at U18B pin 6. When RESET is released, U18B pin 6 goes back high, and the NAND gates used as inverters at U8A pins 1,2-3 and U8D 12,13-11 produce a momentary low at U18A pin 3. After this priming sequence of each XOR going low and high, the priming circuit resumes its steady-state conditions, and the XOR outputs follow the A and B inputs for the time interval measurement.

Channel A Prescaler

Maximum guaranteed operating frequency of the counter chip, U20, is 10 MHz. To extend the frequency range to 175 MHz, the Model 1823 employs a prescaler consisting of two frequency dividers in the Channel A digital input path. The first is a divide-by-ten, IC103, whose input is taken from the output of the Channel A amplifier at IC102 pin 15. This is immediately followed by U19B, a divide-by-two.

The output of U19B is applied to a circuit consisting of the NAND gates U16C/U16D/U17C/U17D which select either the frequency-divided signal or the original-frequency signal from the priming circuit. The selection circuit is governed by the output of U15B pin 6, which goes high only during FREQ MHz mode (also discussed in the paragraphs on "Counter Circuits" below). Whenever this mode is selected, the frequency-divided version is applied to the counter circuits.

The effect of the divide-by-two operation on the input is compensated for by another divide-by-two, U19A, connected between pins 38 and 33 of the ICM7226A. As explained in the "Counter Circuits" paragraphs, whenever FREQ MHz mode is enabled, this circuit divides the counter time base by two.

The effect of the divide-by-ten on the input is compensated by shifting of the display decimal point, also discussed in the "Counter Circuits" paragraphs.

Counter Circuits

ICM7226A Counter

This integrated circuit, U20, is the heart of the unit. It performs all counting functions and multiplexes and drives the displays. It requires an input signal of digital logic levels, as provided by the circuits previously discussed. A crystal for the timebase oscillator is also required, as well as external connections for feedback of display digit strobes, as described below.

Digit Strobes and Feedback

The 7226A multiplexes the display by means of digit strobes D1-D8. Each strobe goes high in sequence, as in Fig. 6, turning its display digit on momentarily. As each digit is selected, the proper seven-segment and decimal point information for that digit is sent out at the same time on pins 8-11 and 13-16.

The digit strobes D1-D8 are also used to control the 7226A by selective feedback to four control pins, 1, 4, 20, and 21. Operating mode, resolution, and other parameters are determined by which strobe signal is present at each control input. Strobe feedback is controlled by the front panel settings through logic. Each control pin and its feedback network is discussed below.

Function Selection

Function selection is controlled by FUNCTION pin 4. As shown in Fig. 7, this pin is connected to one of digit strobes D1-D5 or D8 through electronic switches U9, U10A, U10B via the FUNCtion mode logic circuits consisting of U2, U6E and U6F and FUNCtion switch S4.

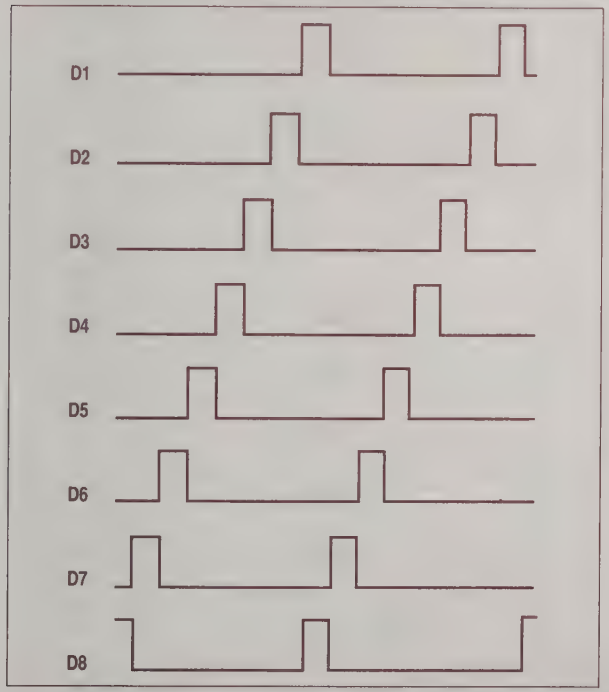

Figure 6. U20 Digit Strobes.

Gate Selection

Gate selection is controlled by RANGE pin 21. As shown in Fig. 8, this pin is directly connected to one of digit strobes D1-D4 through electronic switches U7D/U12B/U11D/U11C via the GATE mode logic circuits consisting of U3, U6D and U6C and GATE switch S5.

Additional Control - Pin 1

Additional control of U20 is provided by feedback of strobes D1, D3, and D8 to CONTROL pin 1. This feedback is determined by the front panel switches via the circuits of Figs. 9 and 10. Outputs A and B in Fig. 9 are high only for the conditions listed. In Fig. 10, these outputs are used to gate the strobes to pin 1 through electronic switches U13A/U13C/U13D.

D8 is applied whenever the 1000/10s GATE Time is selected by GATE switch S5, the kHz/µs-MHz/ms switch is pushed in, and PERiod, TIME Interval, or CHECK modes are is selected by FUNCtion switch S4. IC6 responds by outputting the "Display Test" condition, causing the display to read all eights and decimal points with the OVERFLOW on.

D1 is gated whenever the unit is in FREQ MHz mode. This instructs U20 to use the signal at pin 33 as a time base. This is merely the output of a divide-by-two circuit, U19A, whose input is the regular 10 MHz time base (made available at pin 38). Thus, whenever FREQ MHz mode is used, the time base is divided by two. This divider is included to compensate for the previously discussed divide-by-two used in the input path.

D3 is applied whenever any of the conditions listed in Fig. 9 are true. This instructs U20 to use external decimal point control, as explained in the next section.

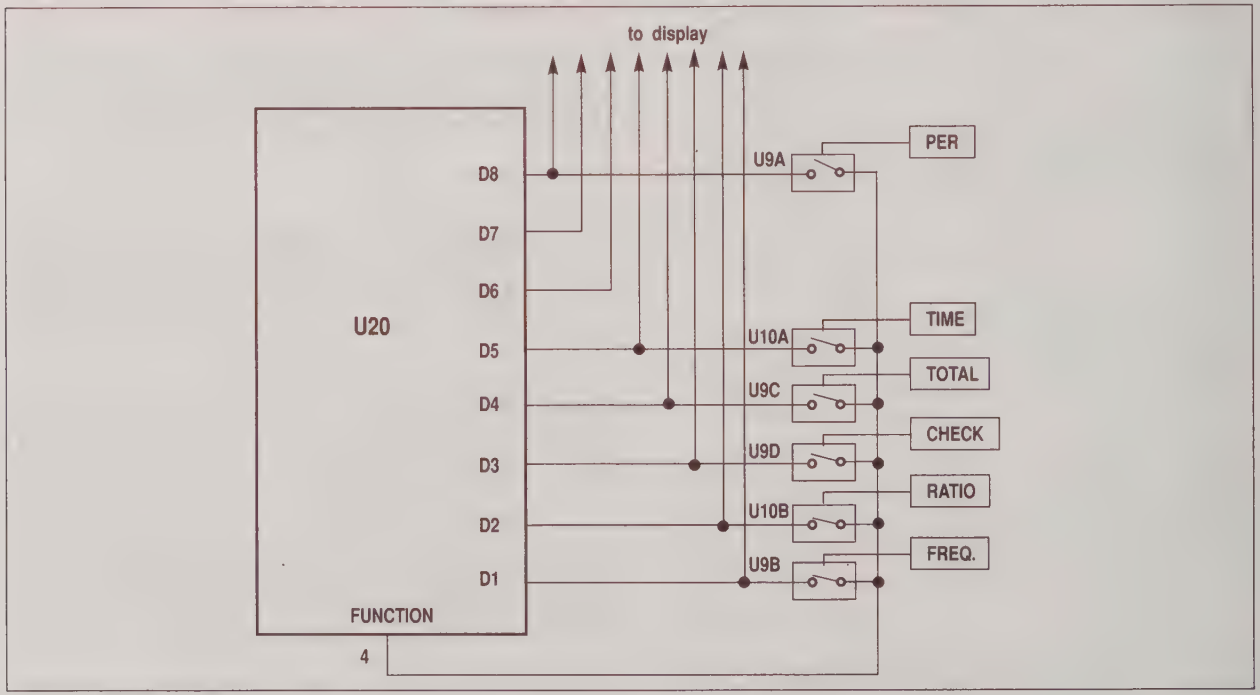

Figure 7. Function Selection.

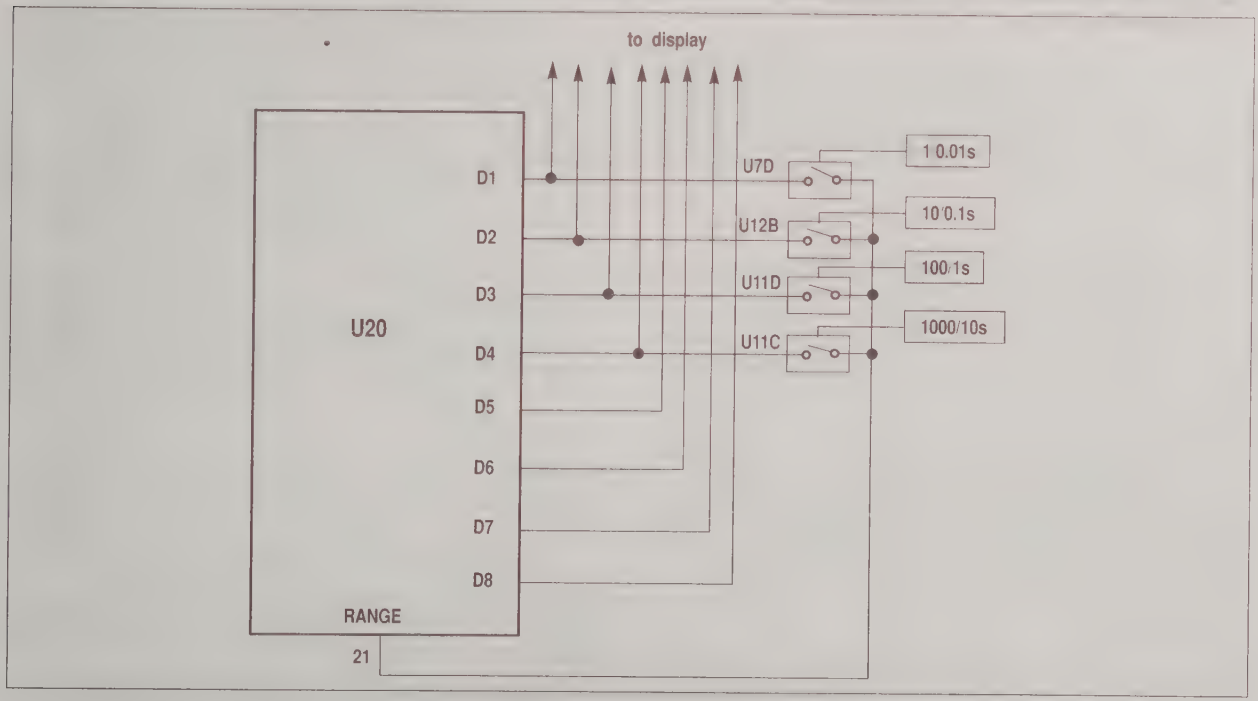

Figure 8. Gate Selection.

External Decimal Point

External decimal point placement is enabled in all of the modes listed in Fig. 9. When D3 is applied to pin 1, the 7226A disables automatic selection, and places a decimal point at the display digit whose strobe is applied to pin 20, EXT DP IN. As shown in Fig. 11, that position is determined partially by the Gate Time selected by the GATE switch S5, and partially by the particular operating mode being used (through outputs A and B of Fig. 9).

Time Base

The Internal time base for the counter is a 10 MHz crystal oscillator circuit consisting of U21D and its associated components with Trimmer capacitor C31 used for calibration. An EXTERNAL 10 MHz Time Base may be applied through the rear panel jack. The INT/EXT switch on the rear panel is used to control U21A,B,C which gates the internal or external time base oscillator to the universal counter U20.

HOLD Switch

Refer to the schematic diagram. The HOLD switch, S2, is connected via U1B and U1C, which provides switch debounce, to U20 and U15C. The connection to U20 instructs the chip to enter the display HOLD mode whenever the switch is engaged. In TOTALize operation, however, U20 would freeze only the display but keep on counting; this is remedied by also connecting S2 to U15C. This cuts off the input from U20 (as does a low at the TOTALIZE START/STOP jack) and halts the counting process.

LED Indicators

The MHz/ms and kHz/µs indicators are connected to complementary signals which are a direct function of the setting of S3, the kHz/µs-MHz/ms switch. They are, however, disabled when U14C pin 8 goes high, in RATIO and TOTALize modes.

The GATE indicator, D26, is connected via inverter U5D (pins 9 and 10) to U20 pin 3. This pin goes low whenever a measurement is in progress.

The OVERFLOW indicator, D27, is connected directly between U20 pins 22 and 8 and lights whenever a "9,9,9,9,9,9,9,9" count has been exceeded.

The FUNCtion indicators; FREQ, PER, RATIO, TIME, TOTAL, and CHECK are connected via inverters U4B/U4F/U4C/U4E/U4D/U4A respectively to the outputs of the Function counter U2. The FUNCtion switch S4 and flip-flop U6E/U6F determines the output of the Function counter. The power-on reset circuit consisting of R7, C20, and U6B connected via D18 assures that U2 Pin 3 will be high initially and the FREQ indicator on.

The GATE indicators; 1/0.01s, 10/0.1s, 100/1.0s, and 1000/10s are connected via inverters U5A,U5F,U5B,U5C respectively to the outputs of the Gate counter U3. The GATE switch S5 and the flip-flop U6C/U6D determines the output of the Gate counter. The power-on reset circuit connected via diode D16 assures that U3 Pin 3 will be high initially and the 1/0.001s indicator on.

Power Supply

The transformer is a universal type whose primary windings may be re-connected for various line voltages by selection of the LINE VOLTAGE SELECT switches S14 and S15 on the rear panel.

The outputs of the transformer secondary windings are fused separately for increased safety and then applied to the rectifier circuits.

The output of one secondary is rectified by bridge D4-D7 and filtered by C10 and C11. Zener diodes D10, D11, D13, and D14 provide regulated +8.2, -8.2, +6.2, and -6.2 volts, respectively.

The other secondary is also rectified by D8 and D9 and filtered by C12. +5 volts is produced by voltage regulator Q1, which provides good regulation and adequate power for the digital portion of the instrument.

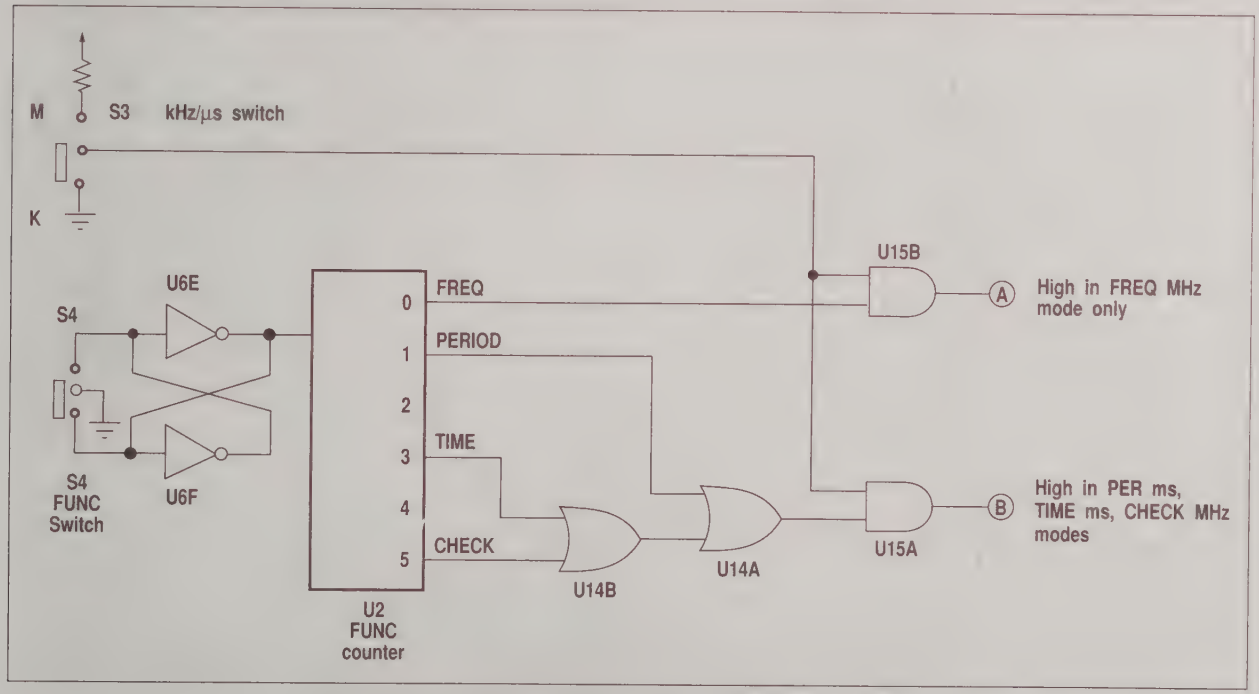

Figure 9. Generation Of Outputs A And B For Figures 10 And 11.

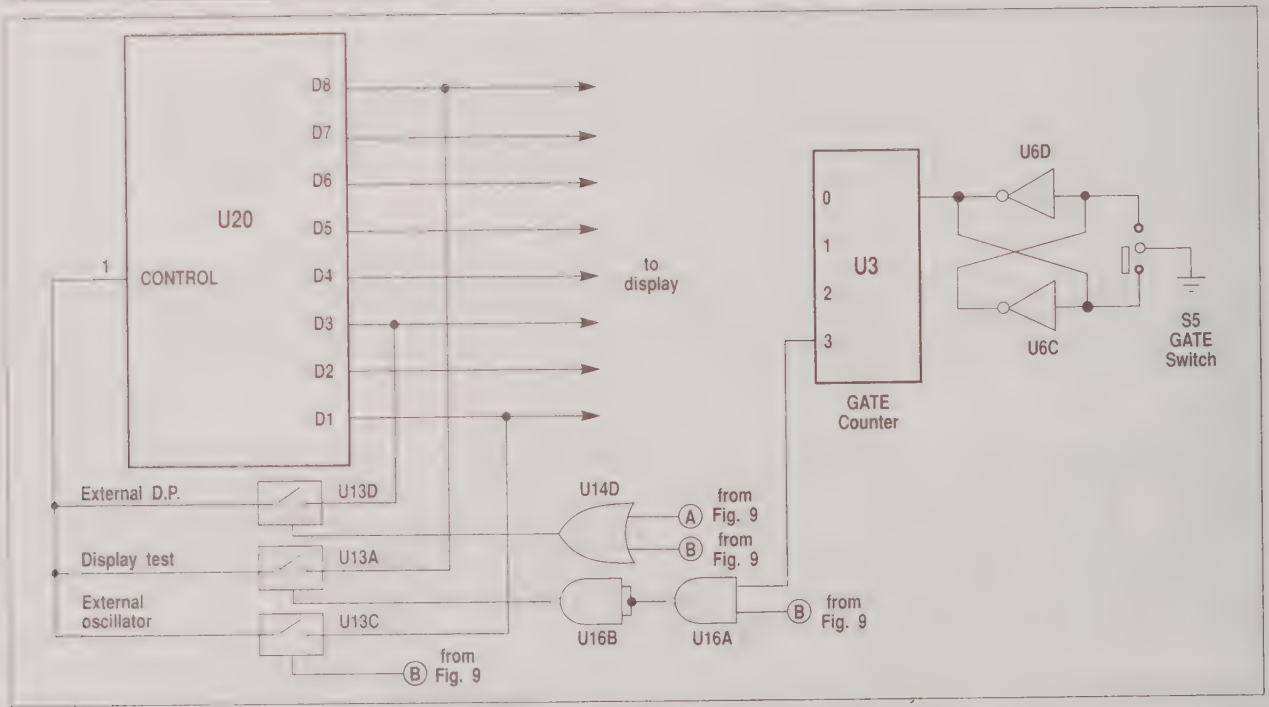

Figure 10. Additional Strobe Feedback; U20 Pin 1.

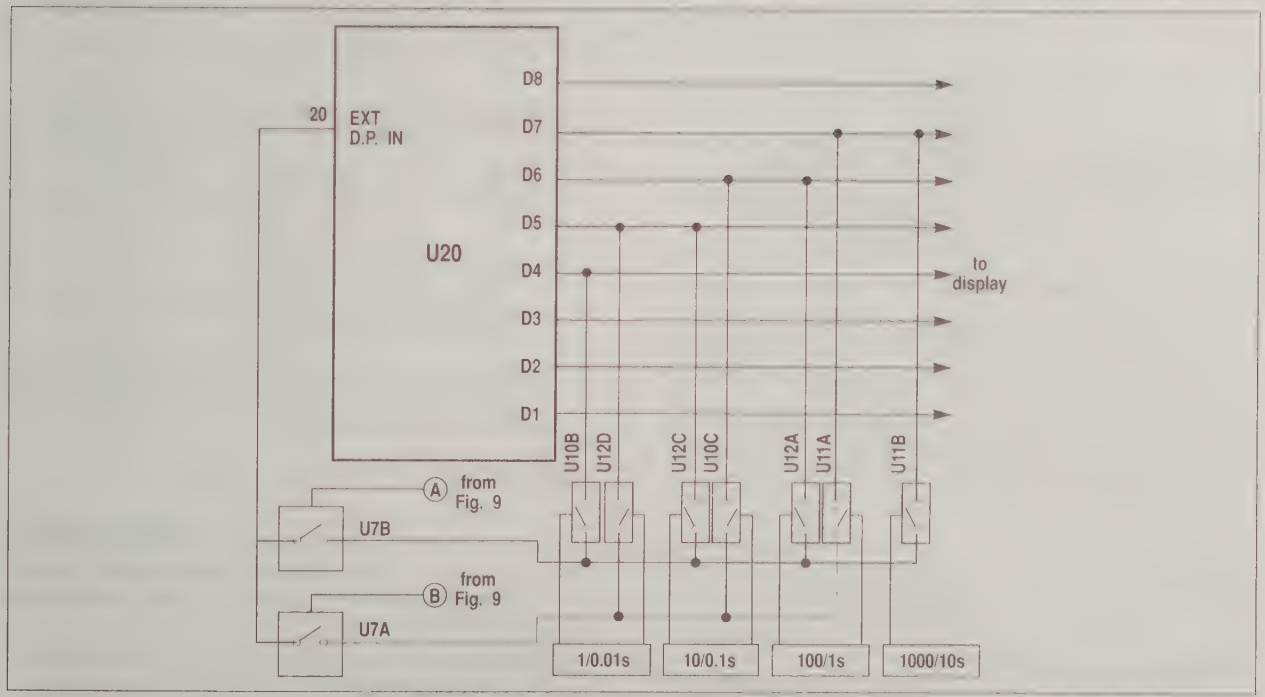

Figure 11. External Decimal Point Control.

MAINTENANCE AND CALIBRATION

WARNING

The following instructions are for use by qualified personnel only. To avoid electrical shock, do not perform any servicing other than contained in the operating instructions unless you are qualified to do so.

FUSE REPLACEMENT

If the primary line fuse FS5 blows, the display and the FUNC or GATE LED indicators will not light and the counter will not operate. The fuse should not normally open unless a problem has developed in the unit. Try to determine and correct the cause of the blown fuse, then replace only with a fuse of the correct rating. For 110 or 120 V operation a 0.2 A, 250 V, 3AG fuse should be used and for 220 or 240 V operation a 0.125 A, 250 V, 3AG fuse should be used. The primary line fuse, FS5, is located on the rear panel (see Fig. 1.b.).

If replacement of the primary line fuse does not alleviate the problem, then one of the four transformer secondary fuses, FS1/FS2/FS3/FS4, may be open. The four fuses are located on the main circuit board (see Fig. 12.). Replace only with a 0.5A, 125 V, 5x20 mm for each.

LINE VOLTAGE CONVERSION

The primary winding of the power transformer is tapped to permit operation from 100, 120, 220, or 240 VAC, 50/60 Hz line voltage. Conversion from one line voltage to another is done by simply changing the LINE VOLTAGE SELECT switches located on the rear panel (see Fig. 1.b.).

To convert to a different line voltage, perform the following procedure:

1. Make sure the power cord is unplugged.
2. Reset the LINE VOLTAGE SELECT switches for the desired line voltage as shown on the rear panel.
3. A change in line voltage may also require a corresponding change of fuse value. Install the correct fuse value as listed in the **FUSE REPLACEMENT** section.

ADJUSTMENTS

This unit was accurately adjusted at the factory before shipment. Readjustment is recommended only if repairs have been made in a circuit affecting adjustment accuracy, or if you have a reason to believe the unit is out of adjustment. However, adjustments should be attempted only if the following equipment is available:

1. 10 MHz Standard with an accuracy of at least 1 PPM and an output level of at least 100 mV rms.
2. RF Generator (Wavetek 3001 or equivalent).

3. RF Millivoltmeter (Booton 92BD or equivalent).

4. DMM with 0.5% DCV Accuracy (B&K Precision 388-HD, 2860 or equivalent).

If readjustment is required, use the following procedure. Locations of the electrical adjustments are shown in Figs. 12 and 13.

ADJUSTMENT	FUNCTION OF ADJUSTMENT
MAIN BOARD	
C31	Time Base Frequency
R111	Channel A Coarse DC Offset
R125	Channel A Trigger Level Balance
R130	Channel A Sensitivity
R182	Channel A Fine DC Offset
CHANNEL B INPUT BOARD	
R147	Channel A Trigger Level Range
R175	Channel B Sensitivity
R179	TIME Interval Accuracy

Table 1. Function of Calibration Adjustments.

Time Base Adjustment

This adjustment should be performed without case top removal and after a one hour warmup.

1. Set the unit for **FREQ A** mode with the **FUNC** switch, **kHz** range with the **kHz**/µs-MHz/ms switch, and a **1.0s** Gate Time with the **GATE** switch.

2. Set the rear panel **TIME BASE SELECT** switch to **INT**.

3. Connect the 10 Mhz standard frequency source to **Channel A Input**.

4. Using a small non-metallic slotted screwdriver, adjust the Time Base Oscillator capacitor **C31** through the rear panel for a a reading of **10000.000** ± 1 Hz on the unit display.

The following adjustments require the removal of the case top; unplug the power cord, turn the unit over and remove the four Phillips screws, two holding the rear rubber feet and the two next to the front rubber feet.

Channel A Sensitivity Adjustments

1. Set the unit to **FREQ A** mode with the **FUNC** switch, **MHz** range with the **kHz**/µs-MHz/ms switch, and **0.01s** Gate time with the **GATE** switch.

2. Push in the **Channel A TRIG LEVEL** control (**PRESET-IN**).

3. Set the DMM for DC Volts, 200.0 mV Range and connect the DMM to **TP1** (IC 101 Pin 1), DMM ground lead to circuit board ground, and adjust **DC OFFSET COARSE** and **FINE** adjustments **R111** and **R182** for a DMM reading of **+5.0 mV** ± 1.0 mV. Disconnect DMM from **TP1**.

4. Connect the RF Generator and the RF Millivoltmeter with a BNC Tee to the **Channel A Input**. Set the RF Generator frequency output to 175.000 MHz and set its level for a reading of 150 mV rms on the RF Millivoltmeter. The counter display should 175.000 ± 1 count.

5. Slowly decrease the RF Generator output level until the counter's least significant digit varies by more than 3 counts. The counter will typically start to read lower.

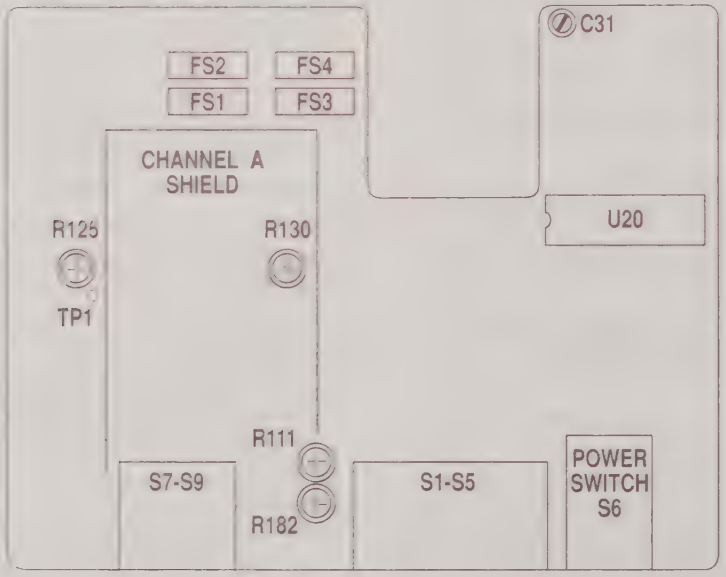

Figure 12. Main Board Adjustments, Component Side View.

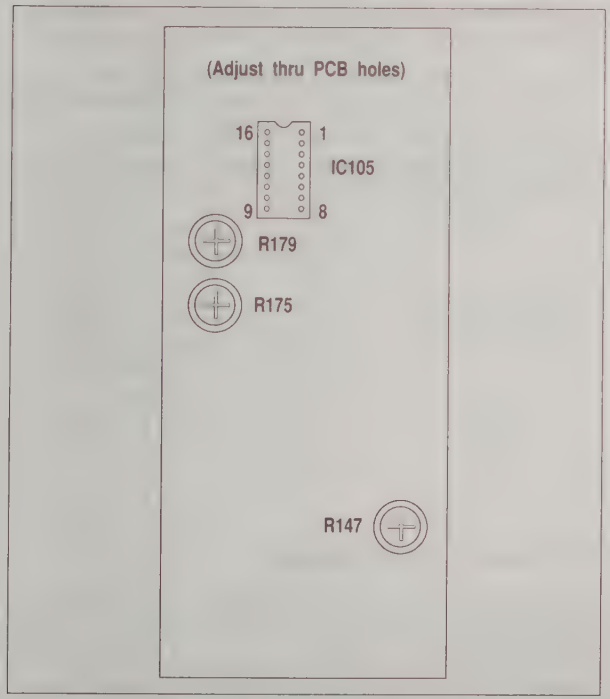

Figure 13. Channel B Input Board, Solder Side View.

6. Adjust the **Channel A Sensitivity Trimmer R130** (through the hole in the metal sheild) so that the counter display reads 175.000 MHz ± 1 count.
7. Repeat steps 5 and 6 until trimmer **R130** no longer can give a stable 175.000 MHz ± 1 count on the display. The typical range of the RF level required would be approximately 75 mV to 125 mV rms.

Channel A TRIG LEVEL Adjustments

1. Set the unit for **FREQ A** mode with the **FUNC** switch, **kHz** range with the **kHz**/µs-MHz/ms switch, and **0.01s** Gate Time with the **GATE** switch.
2. Set the DMM for DC volts, 2 V range and connect it to measure the voltage on the **Channel A TRIG LEVEL** control wiper.
3. Pull out the **TRIG LEVEL** control and turn it fully counterclockwise.
4. Adjust **Trigger Range R147** and **Balance R125** for a reading of **-1.100** ± 0.100 V on the DMM.
5. Rotate the **TRIG LEVEL** control fully clockwise. Adjust **R147** and **R125** for a reading of **+1.500 ± 0.100 V** on the DMM.
6. Repeat steps 3 thru 5 as required to give the **TRIG LEVEL** an approximately -1.1 V to +1.5 V range.
7. Connect the RF Generator/RF Millivoltmeter to the **Channel A Input**.
8. Push in the **TRIG LEVEL** control.
9. Set the RF Generator frequency output to 1.000 MHz and its level for a reading of 400 mV rms on the RF Millivoltmeter. The counter should read 1000.0 ± 1 count.

10. Pull out the TRIG LEVEL control and slowly rotate it fully counterclockwise, then clockwise; the counter should read zero before either end of the TRIG LEVEL control range is reached.

Channel B Sensitivity Adjustments

1. Set the unit for **RATIO A/B** mode with the **FUNC** switch, and **1000 CYCLES AVERAGED** with the **GATE** switch.

2. Connect the 10 MHz Standard to the unit's **Channel A Input** and the RF Generator/RF Millivoltmeter to the **Channel B Input**.

3. Set the RF Generator frequency output to 1.000 MHz and its level for a reading of 30 mV rms on the RF Millivoltmeter. The counter should display 10.000 ± 1 count with the GATE indicator flashing very quickly.

4. Set the DMM for DC volts, 200 mV range and connect between pins 9 and 10 of IC 105, negative lead to pin 9 and positive lead to pin 10.

5. Adjust the **Channel B Sensitivity Trimmer R175** (through the PCB hole of the Channel B Input Board) until the DMM reads **+5.0 mV ± 1.0 mV**. Disconnect the DMM.

6. Change the RF Generator frequency output to 2.000 MHz and its level for a reading of 30 mV rms on the RF Millivoltmeter. The counter should display 5.000 ± 1 count.

TIME Interval Accuracy

1. Set the unit for **TIME A ► B** with the **FUNC** switch, µs range with the **kHz/µs-MHz/ms** switch, and **1 CYCLE AVERAGED** with the **GATE** switch.

2. Set the DMM for DC volts, 200 mV range and connect between pins 9 and 10 of IC105, neative lead to pin 9 and positive lead to pin 10.

3. Adjust the **TIME Interval Accuracy Trimmer R179** (through the PCB hole of the Channel B Input Board) until the DMM reads **–20.0 mV ± 1.0 mV**. Disconnect the DMM.

4. Connect the RF Generator/RF Millivoltmeter to both Channel A and Channel B Inputs.

5. Set RF Generator frequency output to 1.000 MHz and its level for a reading of 100 mV rms on the RF Millivoltmeter.

6. Set the counter's –SL switches into the four combinations and observe the results;

Channel A –SL	Channel B –SL	Counter Display
out (+)	out (+)	1.0 ± 1
out (+)	in (–)	.5 ± 1
in (–)	out (+)	.5 ± 1
in (–)	in (–)	1.0 ± 1

INSTRUMENT REPAIR SERVICE

Because of the specialized skills and test equipment required for instrument repair and calibration, many customers prefer to rely upon **B & K-Precision** for this service. We maintain a network of **B & K-Precision** authorized service agencies for this purpose. To use this service, even if the instrument is no longer under warranty, follow the instructions given in the **WARRANTY SERVICE INSTRUCTIONS** section of this manual. There is a nominal charge for instruments out of warranty.

APPENDIX

A. FREQUENCY/PERIOD TABLES

The tables in this section of the Appendix provide listings of standard audio frequencies in common use in the electronics industry. In each table the frequency and the period are given. Frequency is the reciprocal of period. Divide the period reading into 1 to get frequency.

NOTE: 1 millisecond (ms) = .001 second (s), and 1 microsecond (μs) = .000001 second.

1. **Modem Frequencies.** There are two sets of standard audio frequencies used for data communications:
   a. U.S. Standards.
   b. The Consultative Committee on International Telephone and Telegraph (CCITT).

These frequencies, their periods and corresponding bit pairs are listed in Table 2.

U.S. Standard Frequency (Period)	Bit Pair	CCITT Frequency (Period)
1270 Hz (787.402 μs)	00	980 Hz (1020.41 μs)
1070 Hz (934.579 μs)	01	1180 Hz (847.458 μs)
2225 Hz (449.438 μs)	10	1650 Hz (606.061 μs)
2025 Hz (493.827 μs)	11	1850 Hz (540.540 μs)

Table 2. Modem frequencies.

- Telephone "Touch-Tone" Frequencies. Each of the pushbuttons on a telephone "Touch-Tone" pad activates a pair of frequencies. These tones are used to activate the telephone terminal equipment. The digits on a telephone "Touch-Tone" pad and their respective frequency pairs are listed in Table 3.

"Touch-Tone" is a registered trademark of A.T. & T.

- Scale of equal temperament. Table 4 is included as a source of reference information for the frequency and period of musical notes. This table will be useful when the counter is being used to tune electronic musical instruments.

- Other frequencies. Table 5 lists miscellaneous frequencies commonly encountered, along with their corresponding periods.

B. TIME INTERVAL EXAMPLE

A typical use of the Time Interval mode of the Model 1823 Universal Counter is in measuring the turn-on time of a relay. An example is given in Fig. 14. Here a relay is operated by a control voltage via a transistor switch Q1.

The relay turn-on time is the interval beginning with application of the turn-on command, and ending with relay closure. To measure this interval, Channel A is connected to the control voltage A as shown in fig. 14a. The Channel A -SL switch is left out, so as to start the measurement on a positive-going voltage excursion. Channel B is connected to the moving relay contact. Since in this case relay closure results in a positive transition at the contact, the Channel B -SL switch is also left out, for positive transitions. Depending on the magnitude of V2, the Channel B X10 attenuator may be used to reduce noise.

Digit (Symbol)	Frequencies (Periods)	
1	697 Hz	(1434.72 µs)
	1209 Hz	(827.130 µs)
2	697 Hz	(1434.72 µs)
	1336 Hz	(748.503 µs)
3	697 Hz	(1434.72 µs)
	1477 Hz	(677.948 µs)
4	770 Hz	(1298.70 µs)
	1209 Hz	(827.130 µs)
5	770 Hz	(1298.70 µs)
	1336 Hz	(748.503 µs)
6	770 Hz	(1298.70 µs)
	1477 Hz	(677.048 µs)
7	852 Hz	(1173.71 µs)
	1209 Hz	(827.130 µs)
8	852 Hz	(1173.71 µs)
	1336 Hz	(748.503 µs)
9	852 Hz	(1173.71 µs)
	1477 Hz	(677.048 µs)
0	941 Hz	(1062.69 µs)
	1336 Hz	(748.503 µs)
*	941 Hz	(1062.69 µs)
	1209 Hz	(827.130 µs)
#	941 Hz	(1062.69 µs)
	1477 Hz	(677.048 µs)

Table 3. Telephone "Touch-Tone" pad digits and frequency pairs.

NOTE / FREQ / PERIOD		$C^{\#}_{10}$ 17.324 Hz 57.7234 mS	D_{10} 18.354 Hz 54.4840 mS	$D^{\#}_{10}$ 19.445 Hz 51.4277 mS	E_{10} 20.602 Hz 48.5390 mS	F_{10} 21.826 Hz 45.8169 mS	$F^{\#}_{10}$ 23.125 Hz 43.2432 mS	G_{10} 24.499 Hz 40.8179 mS				
NOTE / FREQ / PERIOD		$C^{\#}_{9}$ 34.647 Hz 28.8625 mS	D_{9} 36.708 Hz 27.2490 mS	$D^{\#}_{9}$ 38.890 Hz 25.7136 mS	E_{9} 41.203 Hz 24.2701 mS	F_{9} 43.653 Hz 22.9709 mS	$F^{\#}_{9}$ 46.249 Hz 21.6221 mS	G_{9} 48.999 Hz 20.4086 mS	$G^{\#}_{9}$ 51.913 Hz 19.2630 mS	A_{9} 55.000 Hz 18.1818 mS		
NOTE / FREQ / PERIOD		$C^{\#}_{8}$ 69.296 Hz 14.4312 mS	$D^{\#}_{8}$ 73.416 Hz 13.6243 mS	$D^{\#}_{8}$ 77.781 Hz 12.8566 mS	E_{8} 82.406 Hz 12.1350 mS	F_{8} 87.307 Hz 11.4538 mS	$F^{\#}_{8}$ 92.498 Hz 10.8110 mS	G_{8} 97.998 Hz 10.2053 mS	$G^{\#}_{8}$ 103.826 Hz 9631.50 µS	A_{8} 110.00 Hz 9090.91 µS	$A^{\#}_{8}$ 116.540 Hz 8580.74 µS	B_{8} 123.472 Hz 8099.13 µS
NOTE / FREQ / PERIOD		$C^{\#}_{7}$ 138.591 Hz 7215.48 µS	D_{7} 146.832 Hz 6812.50 µS	$D^{\#}_{7}$ 155.563 Hz 6428.36 µS	E_{7} 164.813 Hz 6067.48 µS	F_{7} 174.614 Hz 5726.92 µS	$F^{\#}_{7}$ 184.997 Hz	G_{7} 195.997 Hz 5102.12 µS				
NOTE / FREQ / PERIOD		$C^{\#}_{6}$ 277.183 Hz 3607.72 µS	D_{6} 293.664 Hz	$D^{\#}_{6}$ 311.126 Hz 3214.13 µS	E_{6} 329.627 Hz 3033.73 µS		$F^{\#}_{6}$ 369.994 Hz 2702.75 µS	G_{6} 391.995 Hz 2551.05 µS	$G^{\#}_{6}$ 415.304 Hz 2407.87 µS	A_{6} 440.000 Hz 2272.72 µS	$A^{\#}_{6}$ 466.163 Hz 2145.17 µS	B_{6} 493.883 Hz 2024.77 µS
NOTE / FREQ / PERIOD		$C^{\#}_{5}$ 554.365 Hz 1803.86 µS	D_{5} 587.329 Hz	$D^{\#}_{5}$ 622.253 Hz 1607.06 µS	E_{5} 659.255 Hz 1516.86 µS	F_{5} 698.456 Hz 1431.73 µS	$F^{\#}_{5}$ 739.988 Hz 1351.35 µS	G_{5} 783.991 Hz 1275.52 µS	$G^{\#}_{5}$ 830.609 Hz 1203.94 µS	A_{5} 880.000 Hz 1136.36 µS	$A^{\#}_{5}$ 932.327 Hz 1072.59 µS	B_{5} 987.766 Hz 1012.39 µS
NOTE / FREQ / PERIOD		$C^{\#}_{4}$ 1108.730 Hz 901.933 µS	D_{4} 1174.659 Hz 851.311 µS	$D^{\#}_{4}$ 1244.507 Hz 803.531 µS	E_{4} 1318.510 Hz 758.432 µS	F_{4} 1396.912 Hz 715.965 µS	$F^{\#}_{4}$ 1479.976 Hz 675.687 µS	G_{4} 1567.982 Hz 637.762 µS	$G^{\#}_{4}$ 1661.218 Hz 601.968 µS	A_{4} 1760.000 Hz 568.182 µS		
NOTE / FREQ / PERIOD		$C^{\#}_{3}$ 2217.460 Hz 450.966 µS	$D^{\#}_{3}$ 2349.318 Hz 425.655 µS	$D^{\#}_{3}$ 2489.014 Hz 401.766 µS	E_{3} 2637.020 Hz 379.216 µS	F_{3} 2793.824 Hz 357.932 µS	$F^{\#}_{3}$ 2959.952 Hz 337.843 µS	G_{3} 3135.964 Hz 318.881 µS	$G^{\#}_{3}$ 3322.436 Hz 300.984 µS			B_{3} 3951.364 Hz 253.096 µS
NOTE / FREQ / PERIOD		$C^{\#}_{2}$ 4434.920 Hz 225.483 µS	D_{2} 4699.636 Hz 212.782 µS	$D^{\#}_{2}$ 4978.028 Hz 200.833 µS	E_{2} 5274.040 Hz 189.608 µS	F_{2} 5587.648 Hz 178.966 µS	$F^{\#}_{2}$ 5919.904 Hz 168.922 µS	G_{2} 6271.928 Hz 159.441 µS	$G^{\#}_{2}$ 6664.872 Hz 150.493 µS			B_{2} 7902.128 Hz 126.548 µS

Table 4. Scale Of Equal Temperament.

Assuming that relay closures occur once at a time for measurement purposes, the counter is prepared for a single-event measurement, 1 cycle average is selected with the GATE Switch, and the unit is primed by pressing RESET. When the control voltage A goes high (Fig. 14b), the unit starts counting the time interval. After a delay consisting of the turn-on of Q1 and the mechanical movement of the contact, the relay contact voltage B goes to V2, representing the "stop" signal for Channel B. The timing then stops and the display reads the length of the delay interval.

For each subsequent measurement, the unit must be primed by pushing RESET before each relay closure.

C. CONTACT DEBOUNCING

The TOTALize function can be electronically controlled by a logic signal applied to the rear panel TOTALIZE START/STOP jack. In certain applications, this gating may have be provided by a contact closure such as a switch or relay. If the opening or closing of the switch or relay contacts is noisy, inaccurate readings may be obtained due to improper gating.

The problem can be reduced by using pushbutton or toggle switches (slide switches are not recommended) and connecting a 0.22 %F to 0.47 µF non-polarized capacitor across the contacts.

A better solution is to employ a TTL debounce circuit like those shown in Fig. 15. Each of the examples in the figure utilizes a flip-flop; the second circuit is in fact used in the Model 1823 to debounce the HOLD switch. Another type of debounce circuit (not shown) utilizes a 74121 one-shot. When triggered, this circuit produces a pulse (duration determined by external resistor and capacitor) which outlasts the switch chatter. Information on this chip is available in the manufacturer's literature.

Use/Function	Frequency	Period
TV horizontal	15734.26 Hz	63.556 µs
Stereo FM pilot carrier	19,000 Hz	52.631 µs
Test tone	400 Hz	2500.00 µs
Power line (and related) frequencies	60 Hz	16.6667 µs
	50 Hz	20.0000 µs
	30 Hz	33.3333 us
Kansas City standard cassette interface		
"Space"	1200 Hz	833.333 µs
"Mark"	2400 Hz	416.667 µs
16x Clock	4800 Hz	208.333 µs
Amateur RTTY		
"Mark"	2125 Hz	470.588 µs
170 Hz Shift "Space"	2295 Hz	435.730 µs
850 Hz Shift "Space"	2975 Hz	336.134 µs
Amateur slow-scan TV		
Sync	1200 Hz	833.333 µs
Black	1500 Hz	666.667 µs
White	2300 Hz	434.783 µs

Table 5. Miscellaneous frequencies encountered.

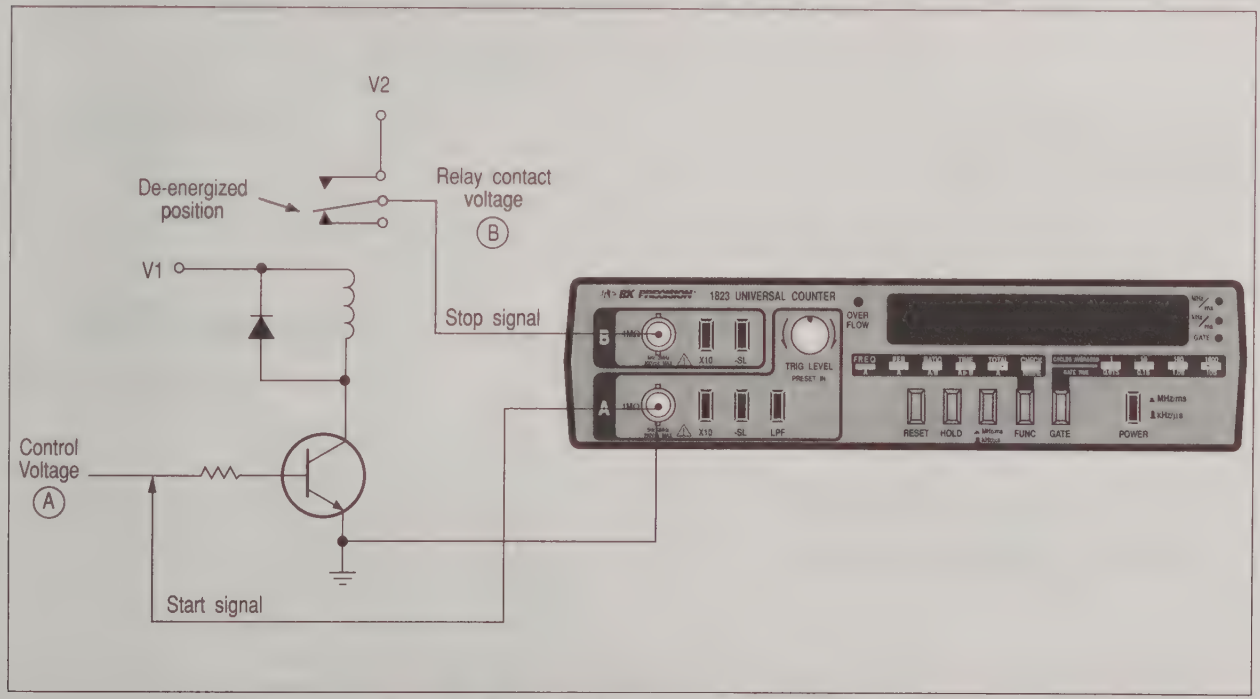

Figure 14a. Time Interval Measurement Example (1 of 2).

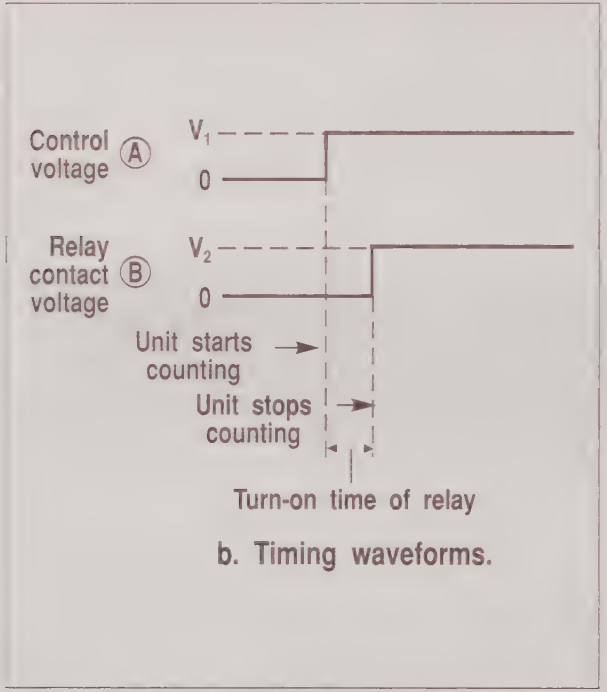

Figure 14b. Time Interval Measurement Example (2 of 2).

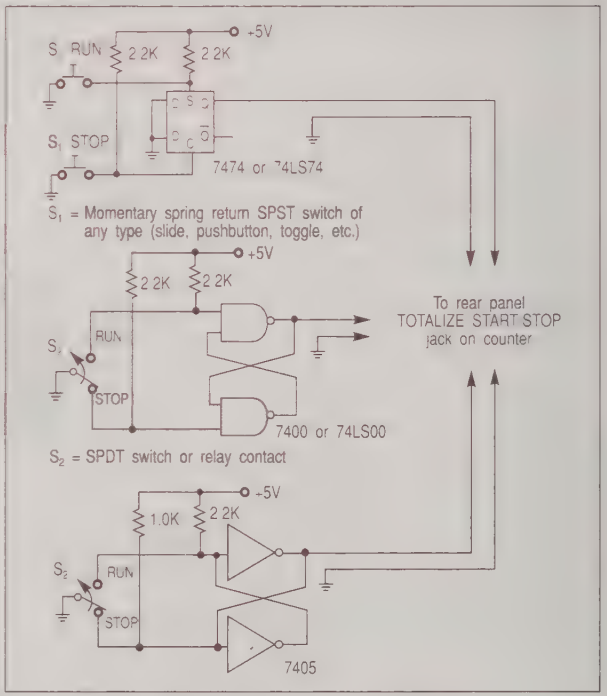

Figure 15. Debouncing Circuits.

ACCESSORIES

ACCESSORIES SUPPLIED

Instruction Manual

Schematic Diagram & Parts List

Detachable Power Cord

OPTIONAL ACCESSORIES AVAILABLE

B&K-Precision Probes

Model	Description
PR-37	Deluxe 10:1/Direct Probe. When used with Channel A counter input, provides input resistance of 10 MΩ in 10:1, 1 MΩ in Direct, and input capacitance of ≤ 12.5 pF in 10:1, ≤80 pF in Direct. Bandwidth of 100 MHz.
PR-46	10:1 Low Capacitance Probe. When used with Channel A counter input, provides input resistance of 10 MΩ and input capacitance of ≤ 16 pF, at fixed 10:1 attenuation. Bandwidth of 250 MHz.
PR-47	10:1 Low Capacitance Probe. When used with Channel A counter input, Provides input resistance of 10 MΩ and input capacitance of ≤ 11.5 pF at fixed 10:1 attenuation. Bandwidth of 100 MHz.

B&K-Precision Cables

Model	Description
CC-41	36″ RG/58U coax, BNC on each end.
CC-42	36″ RG/58U coax, BNC to UHF (PL-259).

B&K-Precision Antenna Kit

Model	Description
AN-18	"Rubber Duckie" Antenna and right angle BNC adaptor.

NOTES:

WARRANTY SERVICE INSTRUCTIONS
(For U.S.A. and its Overseas Territories)

1. Refer to the MAINTENANCE section of your **B & K-Precision** instruction manual for adjustments that may be applicable.
2. If the above-mentioned does not correct the problem you are experiencing with your unit, pack it securely (preferably in the original carton or double-packed).
3. Enclose a letter describing the problem and include your name and address.
4. Enclose proof of purchase date; that is, a dated copy of the sales receipt.
5. Deliver to, or ship PREPAID (UPS preferred in U.S.A.) to the nearest **B & K-Precision** authorized service agency (see list enclosed with unit).

If your list of authorized **B & K-Precision** service agencies has been misplaced, contact your distributor for the name of your nearest service agency, or write to:

B & K-PRECISION,
MAXTEC INTERNATIONAL CORP.
Factory Service Operations
6470 West Cortland Street
Chicago, Illinois 60635
Tel (312) 889-1448
Telex: 25-3475

Also use this address for technical inquiries
and replacement parts orders.

LIMITED ONE-YEAR WARRANTY

MAXTEC INTERNATIONAL CORP. warrants to the original purchaser that its **B & K-Precision** product, and the component parts thereof, will be free from defects in workmanship and materials for a period of one year from the date of purchase.

MAXTEC will, without charge, repair or replace, at its option, defective product or component parts upon delivery to an authorized **B & K-Precision** service contractor or the factory service department, accompanied by proof of the purchase date in the form of a sales receipt.

To obtain warranty coverage in the U.S.A., this product must be registered by completing and mailing the enclosed warranty registration card to **MAXTEC, B & K-Precision**, 6470 West Cortland Street, Chicago, Illinois 60635 within fifteen (15) days from the date of purchase.

Exclusions: This warranty does not apply in the event of misuse or abuse of the product or as a result of unauthorized alterations or repairs. It is void if the serial number is altered, defaced or removed.

MAXTEC shall not be liable for any consequential damages, including without limitation damages resulting from loss of use. Some states do not allow limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific rights and you may also have other rights which vary from state to state.

For your convenience we suggest you contact your **B & K-Precision** distributor, who may be authorized to make repairs or can refer you to the nearest service contractor. If warranty service cannot be obtained locally, please send the unit to **B & K-Precision** Service Department, 6470 West Cortland Street, Chicago, Illinois 60635, properly packaged to avoid damage in shipment.

B & K-Precision Test Instruments warrants products sold only in the U.S.A. and its overseas territories. In other countries, each distributor warrants the **B & K-Precision** products which it sells.

(continued from inside front cover)

6. Use an insulated floor material or a large, insulated floor mat to stand on, and an insulated work surface on which to place equipment; and make certain such surfaces are not damp or wet.

7. Connect the counter's ac power cord only to a polarized 3-wire ac outlet. This assures that the counter's front & rear panels, BNC Input Jacks, and exposed hardware are connected to a good earth ground and reduces danger from electrical shock.

8. Some equipment with a two-wire ac power cord, including some with polarized power plugs, is the "hot chassis" type. This includes most recent television receivers and audio equipment. A plastic or wooden cabinet insulates the chassis to protect the customer. When the cabinet is removed for servicing, a serious shock hazard exists if the chassis is touched. Not only does this present a dangerous shock hazard, but damage to test instruments or the equipment under test may result from connecting an earth ground lead of a test instrument to a "hot chassis". To make measurements in "hot chassis" equipment, always connect an isolation transformer between the ac outlet and the equipment under test. The **B & K-Precision** Model TR-110 or 1604 Isolation Transformer, or Model 1653 or 1655 AC Power Supply is suitable for most applications. To be on the safe side, treat all two-wire ac powered equipment as "hot chassis" unless you are sure it has an isolated chassis or an earth ground chassis.

9. **B & K-Precision** products are not authorized for use in any application involving direct contact between our product and the human body, or for use as a critical component in a life support device or system. Here, "direct contact" refers to any connection from or to our equipment via any cabling or switching means. A "critical component" is any component of a life support device or system whose failure to perform can be reasonably expected to cause failure of that device or system, or to affect its safety or effectiveness.

10. Never work alone. Someone should be nearby to render aid if necessary. Training in CPR (cardio-pulmonary resuscitation) first aid is highly recommended.

B&K PRECISION®

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6470 W. Cortland St. • Chicago, IL 60635

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